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12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			12b. DISTRIBUTION CODE F	
13. ABSTRACT (Maximum 200 words) Remedial Investigation Report of Sites 1-9 at Alpena CRTC, Alpena MI. Volume V Appendices P-W. A remedial investigation was performed on 9 sites at the Alpena CRTC to determine the extent of contamination at the sites. The sites involved in this investigation include: Site 1 POL Storage Area; Site 2 Motor Pool Area; Site 3 Former Garage; Site 4 Third Fire Training Area; Site 5 Second Fire Training Area; Site 6 Former Landfill; Site 7 First Fire Training Area; Site 8 Former Hanger 9; Site 10 Hazardous Waste Storage Area. Soil and groundwater contamination above state action levels was found at the sites. An FS has been initiated.				
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INSTALLATION RESTORATION PROGRAM

FINAL REMEDIAL INVESTIGATION REPORT

VOLUME V: APPENDICES P - W

ALPENA COMBAT READINESS TRAINING CENTER
ALPENA COUNTY REGIONAL AIRPORT, MICHIGAN AIR NATIONAL GUARD
ALPENA, MICHIGAN

JUNE 1995



19950710 053

HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
Environmental Restoration and Waste Management Programs
Oak Ridge, Tennessee 37831-7606
managed by MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the U.S. DEPARTMENT OF ENERGY under contract DE-AC05-84OR21400

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Table P-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 1
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0820
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	1,4-Dichlorobenzene	25.0000
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Antimony, Dissolved	39.2000
PC-P1	MW12	PC-P1-MW12-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW13	PC-P1-MW13-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW2	PC-P1-MW2-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW3	PC-P1-MW3-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW4	PC-P1-MW4-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	Antimony, Dissolved	39.2000
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	Antimony, Dissolved	13.0000
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Benzen	0.6000
PC-P1	MW12	PC-P1-MW12-GW4	GROUNDWATER	Benzen	0.1750
PC-P1	MW13	PC-P1-MW13-GW4	GROUNDWATER	Benzen	0.1750
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	Benzen	0.1100
PC-P1	MW2	PC-P1-MW2-GW4	GROUNDWATER	Benzen	0.1750
PC-P1	MW3	PC-P1-MW3-GW4	GROUNDWATER	Benzen	0.0900
PC-P1	MW4	PC-P1-MW4-GW4	GROUNDWATER	Benzen	0.1750
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	Benzen	10.0000
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	Benzen	0.2000
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW12	PC-P1-MW12-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW13	PC-P1-MW13-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW2	PC-P1-MW2-GW4	GROUNDWATER	Bromodichloromethane	0.7800
PC-P1	MW3	PC-P1-MW3-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW4	PC-P1-MW4-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Dibenzofuran	2.5000

Table P-1A (continued)
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 1
MIANG, Alpena CRTG, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-P1	MW12	PC-P1-MW12-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW13	PC-P1-MW13-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW2	PC-P1-MW2-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW3	PC-P1-MW3-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW4	PC-P1-MW4-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	Dibenzofuran	1.0000
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW12	PC-P1-MW12-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW13	PC-P1-MW13-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW2	PC-P1-MW2-GW4	GROUNDWATER	Dibromochloromethane	2.1000
PC-P1	MW3	PC-P1-MW3-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW4	PC-P1-MW4-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW12	PC-P1-MW12-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW13	PC-P1-MW13-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW2	PC-P1-MW2-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW3	PC-P1-MW3-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW4	PC-P1-MW4-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	Styrene	0.1250
PC-PW	PW1	PC-PW-PW1-GW4	GROUNDWATER	Carbon Tetrachloride	8.5000
PC-PW	PW2	PC-PW-PW2-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-PW	PW3	PC-PW-PW3-GW4	GROUNDWATER	Carbon Tetrachloride	1.2000

Table P-2A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Sediment - Site 1
MIANG, Alpena CRTG, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE	RESULT
PC-P1	SD001	PC-P1-SD001	SEDIMENT	Arsenic	0.0000	3.0000
PC-P1	SD002	PC-P1-SD002	SEDIMENT	Arsenic	0.0000	5.8000
PC-P1	SD003	PC-P1-SD003	SEDIMENT	Arsenic	0.0000	0.9600
PC-P1	SD005	PC-P1-SD005	SEDIMENT	Arsenic	0.0000	3.4000
PC-P1	SD001	PC-P1-SD001	SEDIMENT	Copper	0.0000	2.3000
PC-P1	SD002	PC-P1-SD002	SEDIMENT	Copper	0.0000	5.3000
PC-P1	SD003	PC-P1-SD003	SEDIMENT	Copper	0.0000	0.9500
PC-P1	SD005	PC-P1-SD005	SEDIMENT	Copper	0.0000	24.0000

Table P-3A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Subsoils - Site 1
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE	RESULT
PC-P1	SB01	PC-P1-SB01	SUBSOIL	Chlorobenzene	0.0000	2.1000
PC-P1	SB01	PC-P1-SB01	SUBSOIL	Chlorobenzene	0.0000	6200.0000
PC-P1	SB02	PC-P1-SB02	SUBSOIL	Chlorobenzene	0.0000	1.9000
PC-P1	SB02	PC-P1-SB02	SUBSOIL	Chlorobenzene	0.0000	0.3100
PC-P1	SB03	PC-P1-SB03	SUBSOIL	Chlorobenzene	0.0000	2.0000
PC-P1	SB03	PC-P1-SB03	SUBSOIL	Chlorobenzene	0.0000	1.9000
PC-P1	SB01	PC-P1-SB01	SUBSOIL	Ethylbenzene	0.0000	0.2000
PC-P1	SB01	PC-P1-SB01	SUBSOIL	Ethylbenzene	0.0000	7900.0000
PC-P1	SB02	PC-P1-SB02	SUBSOIL	Ethylbenzene	0.0000	1.9000
PC-P1	SB02	PC-P1-SB02	SUBSOIL	Ethylbenzene	0.0000	0.1400
PC-P1	SB03	PC-P1-SB03	SUBSOIL	Ethylbenzene	0.0000	2.0000
PC-P1	SB03	PC-P1-SB03	SUBSOIL	Ethylbenzene	0.0000	1.9000
PC-P1	SB01	PC-P1-SB01	SUBSOIL	Styrene	0.0000	1.8000
PC-P1	SB01	PC-P1-SB01	SUBSOIL	Styrene	0.0000	7800.0000
PC-P1	SB02	PC-P1-SB02	SUBSOIL	Styrene	0.0000	1.6000
PC-P1	SB02	PC-P1-SB02	SUBSOIL	Styrene	0.0000	0.6600
PC-P1	SB03	PC-P1-SB03	SUBSOIL	Styrene	0.0000	1.7000
PC-P1	SB03	PC-P1-SB03	SUBSOIL	Styrene	0.0000	1.6000

TABLE P-1 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF GROUNDWATER
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	RECREATIONAL/ON-SITE	
	ADULT	CHILD
Ingestion Rate (L/day)	2	2
Exposure Frequency (days/year)	298 *	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time	70	70
Carcinogens	25	15
Noncarcinogens		

*Worst case scenario assumes the facility employee and recreational adult are the same person. The facility employee is on-site 250 days/year as an employee and uses the recreational facilities an additional 48 days/year for a total exposure frequency of 298 days/year.

TABLE P-2 DAILY INTAKE - ADULT
INGESTION OF SHALLOW AQUIFER PRODUCTION WELL GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
 Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.700E-04	2	298	25	70	9125	6.298E-06
Antimony, Dissolved	1.400E-03	2	298	25	70	9125	3.266E-05
Bromodichloromethane	9.000E-06	2	298	25	70	9125	2.099E-07
Dibromochloromethane	2.600E-05	2	298	25	70	9125	6.065E-07
Dibenzofuran	5.000E-06	2	298	25	70	9125	1.166E-07
1,4-Dichlorobenzene	1.500E-06	2	298	25	70	9125	3.499E-08
Styrene	2.600E-06	2	298	25	70	9125	6.065E-08
Carbon Tetrachloride	1.200E-03	2	298	25	70	9125	2.799E-05

TABLE P-3 DAILY INTAKE - CHILD
INGESTION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
 Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.700E-04	2.000	48	15	27	5475	2.630E-06
Antimony, Dissolved	1.400E-03	2.000	48	15	27	5475	1.364E-05
Bromodichloromethane	9.000E-06	2.000	48	15	27	5475	8.767E-08
Dibromochloromethane	2.600E-05	2.000	48	15	27	5475	2.533E-07
Dibenzofuran	5.000E-06	2.000	48	15	27	5475	4.871E-08
1,4-Dichlorobenzene	1.500E-06	2.000	48	15	27	5475	1.461E-08
Styrene	2.600E-06	2.000	48	15	27	5475	2.533E-08
Carbon Tetrachloride	1.200E-03	2.000	48	15	27	5475	1.169E-05

TABLE P-4 DAILY INTAKE - ADULT
INGESTION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
 Site 1, Former POL Facility, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.700E-04	2	298	25	70	25550	2.249E-06
Antimony, Dissolved	1.400E-03	2	298	25	70	25550	1.166E-05
Bromodichloromethane	9.000E-06	2	298	25	70	25550	7.498E-08
Dibromochloromethane	2.600E-05	2	298	25	70	25550	2.166E-07
Dibenzofuran	5.000E-06	2	298	25	70	25550	4.166E-08
1,4-Dichlorobenzene	1.500E-06	2	298	25	70	25550	1.250E-08
Styrene	2.600E-06	2	298	25	70	25550	2.166E-08
Carbon Tetrachloride	1.200E-03	2	298	25	70	25550	9.997E-06

TABLE P-5 DAILY INTAKE - CHILD
INGESTION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
 Site 1, Former POL Facility, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.700E-04	2.000	48	15	27	25550	5.636E-07
Antimony, Dissolved	1.400E-03	2.000	48	15	27	25550	2.922E-06
Bromodichloromethane	9.000E-06	2.000	48	15	27	25550	1.879E-08
Dibromochloromethane	2.600E-05	2.000	48	15	27	25550	5.427E-08
Dibenzofuran	5.000E-06	2.000	48	15	27	25550	1.044E-08
1,4-Dichlorobenzene	1.500E-06	2.000	48	15	27	25550	3.131E-09
Styrene	2.600E-06	2.000	48	15	27	25550	5.427E-09
Carbon Tetrachloride	1.200E-03	2.000	48	15	27	25550	2.505E-06

TABLE P-6 EXPOSURE ASSESSMENT PARAMETERS - INHALATION OF GROUNDWATER
Site 1, Former POL Facility, Alpena CRTG, Alpena, MI

PARAMETER	ADULT	CHILD
Exposure Time (hours/day)	0.12	0.12
Inhalation Rate (cu m/hr)	0.6	0.6
Exposure Frequency (days/yr)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE P-7 DAILY INTAKE - ADULT
INHALATION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.550E-03	0.6	298	0.12	25	70	9125	2.142E-06
Antimony, Dissolved		0.6	298	0.12	25	70	9125	0.000E+00
Bromodichloromethane	8.501E-05	0.6	298	0.12	25	70	9125	7.139E-08
Dibromochloromethane	2.456E-04	0.6	298	0.12	25	70	9125	2.062E-07
Dibenzofuran		0.6	298	0.12	25	70	9125	0.000E+00
1,4-Dichlorobenzene	1.417E-05	0.6	298	0.12	25	70	9125	1.190E-08
Styrene	2.456E-05	0.6	298	0.12	25	70	9125	2.062E-08
Carbon Tetrachloride	1.134E-02	0.6	298	0.12	25	70	9125	9.519E-06

TABLE P-8 DAILY INTAKE - CHILD
INHALATION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.550E-03	0.6	48	0.12	15	27	5475	8.944E-07
Antimony, Dissolved		0.6	48	0.12	15	27	5475	0.000E+00
Bromodichloromethane	8.501E-05	0.6	48	0.12	15	27	5475	2.981E-08
Dibromochloromethane	2.456E-04	0.6	48	0.12	15	27	5475	8.613E-08
Dibenzofuran		0.6	48	0.12	15	27	5475	0.000E+00
1,4-Dichlorobenzene	1.417E-05	0.6	48	0.12	15	27	5475	4.969E-09
Styrene	2.456E-05	0.6	48	0.12	15	27	5475	8.613E-09
Carbon Tetrachloride	1.134E-02	0.6	48	0.12	15	27	5475	3.975E-06

TABLE P-9 DAILY INTAKE - ADULT
INHALATION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment

Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.550E-03	0.6	298	0.12	25	70	25550	7.649E-07
Antimony, Dissolved		0.6	298	0.12	25	70	25550	0.000E+00
Bromodichloromethane	8.501E-05	0.6	298	0.12	25	70	25550	2.550E-08
Dibromochloromethane	2.456E-04	0.6	298	0.12	25	70	25550	7.366E-08
Dibenzofuran		0.6	298	0.12	25	70	25550	0.000E+00
1,4-Dichlorobenzene	1.417E-05	0.6	298	0.12	25	70	25550	4.250E-09
Styrene	2.456E-05	0.6	298	0.12	25	70	25550	7.366E-09
Carbon Tetrachloride	1.134E-02	0.6	298	0.12	25	70	25550	3.400E-06

TABLE P-10 DAILY INTAKE - CHILD
INHALATION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment

Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.550E-03	0.6	48	0.12	15	27	25550	1.917E-07
Antimony, Dissolved		0.6	48	0.12	15	27	25550	0.000E+00
Bromodichloromethane	8.501E-05	0.6	48	0.12	15	27	25550	6.389E-09
Dibromochloromethane	2.456E-04	0.6	48	0.12	15	27	25550	1.846E-08
Dibenzofuran		0.6	48	0.12	15	27	25550	0.000E+00
1,4-Dichlorobenzene	1.417E-05	0.6	48	0.12	15	27	25550	1.065E-09
Styrene	2.456E-05	0.6	48	0.12	15	27	25550	1.846E-09
Carbon Tetrachloride	1.134E-02	0.6	48	0.12	15	27	25550	8.518E-07

TABLE P-11 GROUNDWATER INHALATION MODEL CALCULATIONS
Site 1, Former POL Facility, Alpena CRTG, Alpena, MI

Chemicals	Chemical Concentration (mg/L)	Fraction Volatilized (unitless)	Water Flow Rate (L/hr)	Showering Duration Period (hr)	Post Showering Duration Period (hr)	Bathroom Volume (cu m)	Showering Maximum Contaminant Concn'n in Air (mg/cu m)	During and After Showering MAX Contaminant Concn'n in Air (mg/cu m)
Benzene	2.700E-04	0.7	750	0.25	0.35	11	3.222E-03	2.550E-03
Antimony, Dissolved	1.400E-03	0.7	750	0.25	0.35	11	1.670E-02	1.322E-02
Bromodichloromethane	9.000E-06	0.7	750	0.25	0.35	11	1.074E-04	8.501E-05
Dibromochloromethane	2.600E-05	0.7	750	0.25	0.35	11	3.102E-04	2.456E-04
Dibenzofuran	5.000E-06	0.7	750	0.25	0.35	11	5.966E-05	4.723E-05
1,4-Dichlorobenzene	1.500E-06	0.7	750	0.25	0.35	11	1.790E-05	1.417E-05
Styrene	2.600E-06	0.7	750	0.25	0.35	11	3.102E-05	2.456E-05
Carbon Tetrachloride	1.200E-03	0.7	750	0.25	0.35	11	1.432E-02	1.134E-02

TABLE P-12 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH GROUNDWATER
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	0.25	0.25
Dermal Permeability Constant *	0.00084	0.00084
Exposure Frequency (days/year)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	

* Predicted PC (Table 5-7 of U.S. EPA, 1992a)

TABLE P-13 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTIC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	(a) 2.700E-04	0.1	19400	298	0.25	25	70	9125	0.001	1.527E-06
Antimony, Dissolved	(c) 1.400E-03	0.001	19400	298	0.25	25	70	9125	0.001	7.919E-08
Bromodichloromethane	(b) 9.000E-06	0.0058	19400	298	0.25	25	70	9125	0.001	2.953E-09
Dibromochloromethane	(b) 2.600E-05	0.0039	19400	298	0.25	25	70	9125	0.001	5.736E-09
Dibenzofuran	5.000E-06	0.0084	19400	298	0.25	25	70	9125	0.001	2.378E-10
1,4-Dichlorobenzene	(b) 1.500E-06	0.062	19400	298	0.25	25	70	9125	0.001	5.261E-09
Styrene	2.600E-06	0.0084	19400	298	0.25	25	70	9125	0.001	1.235E-10
Carbon Tetrachloride	1.200E-03	0.022	19400	298	0.25	25	70	9125	0.001	1.493E-06

(a) Experimentally measured PC (Table 5-3 of U. S. EPA, 1992a).

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC value (Table 5-3 of U. S. EPA, 1992a).

TABLE P-14 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTIC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	(a) 2.700E-04	0.1	13300	48	0.25	15	27	5475	0.001	4.373E-07
Antimony, Dissolved	(c) 1.400E-03	0.001	13300	48	0.25	15	27	5475	0.001	2.267E-08
Bromodichloromethane	(b) 9.000E-06	0.0058	13300	48	0.25	15	27	5475	0.001	8.454E-10
Dibromochloromethane	(b) 2.600E-05	0.0039	13300	48	0.25	15	27	5475	0.001	1.642E-09
Dibenzofuran	5.000E-06	0.0084	13300	48	0.25	15	27	5475	0.001	6.802E-11
1,4-Dichlorobenzene	(b) 1.500E-06	0.062	13300	48	0.25	15	27	5475	0.001	1.506E-09
Styrene	2.600E-06	0.0084	13300	48	0.25	15	27	5475	0.001	3.537E-11
Carbon Tetrachloride	1.200E-03	0.022	13300	48	0.25	15	27	5475	0.001	4.275E-07

(a) Experimentally measured PC (Table 5-3 of U. S. EPA, 1992a).

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC value (Table 5-3 of U. S. EPA, 1992a).

TABLE P-15 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	(a) 2.700E-04	0.1	19400	298	0.25	25	70	25550	0.001	5.465E-07
Antimony, Dissolved	(c) 1.400E-03	0.001	19400	298	0.25	25	70	25550	0.001	2.828E-08
Bromodichloromethane	(b) 9.000E-06	0.0058	19400	298	0.25	25	70	25550	0.001	1.055E-09
Dibromochloromethane	(b) 2.600E-05	0.0039	19400	298	0.25	25	70	25550	0.001	2.049E-09
Dibenzofuran	(b) 5.000E-06	0.0084	19400	298	0.25	25	70	25550	0.001	8.485E-11
1,4-Dichlorobenzene	(b) 1.500E-06	0.062	19400	298	0.25	25	70	25550	0.001	1.879E-09
Styrene	2.600E-06	0.0084	19400	298	0.25	25	70	25550	0.001	4.412E-11
Carbon Tetrachloride	1.200E-03	0.022	19400	298	0.25	25	70	25550	0.001	5.334E-07

(a) Experimentally measured PC (Table 5-3 of U. S. EPA, 1992a).

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC value (Table 5-3 of U. S. EPA, 1992a).

TABLE P-16 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	(a) 2.700E-04	0.1	13300	48	0.25	15	27	25550	0.001	9.370E-08
Antimony, Dissolved	(c) 1.400E-03	0.001	13300	48	0.25	15	27	25550	0.001	4.858E-09
Bromodichloromethane	(b) 9.000E-06	0.0058	13300	48	0.25	15	27	25550	0.001	1.812E-10
Dibromochloromethane	(b) 2.600E-05	0.0039	13300	48	0.25	15	27	25550	0.001	3.519E-10
Dibenzofuran	(b) 5.000E-06	0.0084	13300	48	0.25	15	27	25550	0.001	1.458E-11
1,4-Dichlorobenzene	(b) 1.500E-06	0.062	13300	48	0.25	15	27	25550	0.001	3.227E-10
Styrene	2.600E-06	0.0084	13300	48	0.25	15	27	25550	0.001	7.579E-12
Carbon Tetrachloride	1.200E-03	0.022	13300	48	0.25	15	27	25550	0.001	8.162E-08

(a) Experimentally measured PC (Table 5-3 of U. S. EPA, 1992a).

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC value (Table 5-3 of U. S. EPA, 1992a).

TABLE P-17 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH SOILS
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Skin Surface Area Available for Contact (cm ² /day)	3120
Soil to Skin Adherence Factor (mg/cm ²)	2.77
Absorption Factor, Unitless	0.01
Metals	0.25
Organics	250
Exposure Factor (days/year)	0.08
Exposure Duration (year)	70
Body Weight (kilograms)	1E-06
Conversion Factor	0.08
Averaging Time, years	

**TABLE P-18 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS**

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTG, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Chlorobenzene	3.118E+00	1.00E-06	3120	2.77	0.25	250	0.08	70	28.2	6.588E-05
Ethylbenzene	3.970E+00	1.00E-06	3120	2.77	0.25	250	0.08	70	28.2	8.384E-05
Styrene	3.920E+00	1.00E-06	3120	2.77	0.25	250	0.08	70	28.2	8.288E-05

TABLE P-19 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment

Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Soil to Skin Adherence (mg/cm ²)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Chlorobenzene	3.110E+00	1.0E-06	3120	2.77	0.25	250	0.08	70	25550	7.529E-08
Ethylbenzene	3.970E+00	1.0E-06	3120	2.77	0.25	250	0.08	70	25550	9.593E-08
Styrene	3.820E+00	1.0E-06	3120	2.77	0.25	250	0.08	70	25550	8.472E-08

TABLE P-20 EXPOSURE ASSESSMENT PARAMETERS - SOIL INGESTION
Site 1, Former POL Facility, Alpena CRTG, Alpena, MI

PARAMETER	EXCAVATION WORKER
Ingestion Rate (mg/day)	480
Fraction Ingested from Contaminated Sources (unitless)	1
Exposure Frequency (days/year)	250
Exposure Duration (years)	0.08
Body Weight (kilograms)	70
Conversion Factor	1E-06
Averaging Time	
Carcinogenic	70
Noncarcinogenic	0.08

TABLE P-21 DAILY INTAKE - ADULT
SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Excavation Worker Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Excavation Worker Intake Rate (mg/kg-day)
Chlorobenzene	3.116E+03	1E-06	480	1	250	0.08	70	29.2	1.464E-02
Ethylbenzene	3.970E+03	1E-06	480	1	250	0.08	70	29.2	1.865E-02
Styrene	3.920E+03	1E-06	480	1	250	0.08	70	29.2	1.841E-02

TABLE P-22 DAILY INTAKE - ADULT
SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION AND PLANT EMPLOYEES

Carcinogenic Effect Exposure Assessment

Site 1, Former POL Facility, Alpena GRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Excavation Worker Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Excavation Worker Intake Rate (mg/kg-day)
Chlorobenzene	3.118E+03	1E-06	480	1	250	0.08	70	25550	1.673E-05
Ethylbenzene	3.970E+03	1E-06	480	1	250	0.08	70	25550	2.131E-05
Styrene	3.920E+03	1E-06	480	1	250	0.08	70	25550	2.104E-05

TABLE P-23 EXPOSURE ASSESSMENT PARAMETERS - FISH INGESTION
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Fraction of Fish Ingested, unitless	0.5	0.5
Ingestion rate kg/day	0.054	0.043
Exposure Frequency days/yr	26	26
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

**TABLE P-24 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO**

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/kg-day)
Benzene	3.840E-03	0.054	26	0.5	25	70	9125	1.055E-07
Antimony, Dissolved	9.000E-06	0.054	26	0.5	25	70	9125	2.473E-10
Bromodichloromethane	6.900E-04	0.054	26	0.5	25	70	9125	1.896E-08
Dibromochloromethane	3.450E-05	0.054	26	0.5	25	70	9125	9.479E-10
Dibenzofuran	5.000E-06	0.054	26	0.5	25	70	9125	1.374E-10
1,4-Dichlorobenzene	1.200E-04	0.054	26	0.5	25	70	9125	3.297E-09
Styrene	6.500E-01	0.054	26	0.5	25	70	9125	1.786E-05
Carbon Tetrachloride	1.000E-05	0.054	26	0.5	25	70	9125	2.748E-10

**TABLE P-26 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO**

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/kg-day)
Benzene	3.840E-03	0.043	26	0.5	15	27	5475	2.178E-07
Antimony, Dissolved	9.000E-06	0.043	26	0.5	15	27	5475	5.105E-10
Bromodichloromethane	6.900E-04	0.043	26	0.5	15	27	5475	3.914E-08
Dibromochloromethane	3.450E-05	0.043	26	0.5	15	27	5475	1.957E-09
Dibenzofuran	5.000E-06	0.043	26	0.5	15	27	5475	2.836E-10
1,4-Dichlorobenzene	1.200E-04	0.043	26	0.5	15	27	5475	6.807E-09
Styrene	6.500E-01	0.043	26	0.5	15	27	5475	3.687E-05
Carbon Tetrachloride	1.000E-05	0.043	26	0.5	15	27	5475	5.672E-10

**TABLE P-26 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO**

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTIC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	3.840E-03	0.054	26	0.5	25	70	25550	3.768E-08
Antimony, Dissolved	9.000E-06	0.054	26	0.5	25	70	25550	8.831E-11
Bromodichloromethane	6.900E-04	0.054	26	0.5	25	70	25550	6.771E-09
Dibromochloromethane	3.450E-05	0.054	26	0.5	25	70	25550	3.385E-10
Dibenzofuran	5.000E-06	0.054	26	0.5	25	70	25550	4.906E-11
1,4-Dichlorobenzene	1.200E-04	0.054	26	0.5	25	70	25550	1.178E-09
Styrene	6.500E-01	0.054	26	0.5	25	70	25550	6.378E-06
Carbon Tetrachloride	1.000E-05	0.054	26	0.5	25	70	25550	9.813E-11

**TABLE P-27 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO**

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTIC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	3.840E-03	0.043	26	0.5	15	27	25550	4.667E-08
Antimony, Dissolved	9.000E-06	0.043	26	0.5	15	27	25550	1.094E-10
Bromodichloromethane	6.900E-04	0.043	26	0.5	15	27	25550	8.387E-09
Dibromochloromethane	3.450E-05	0.043	26	0.5	15	27	25550	4.193E-10
Dibenzofuran	5.000E-06	0.043	26	0.5	15	27	25550	6.077E-11
1,4-Dichlorobenzene	1.200E-04	0.043	26	0.5	15	27	25550	1.459E-09
Styrene	6.500E-01	0.043	26	0.5	15	27	25550	7.901E-06
Carbon Tetrachloride	1.000E-05	0.043	26	0.5	15	27	25550	1.215E-10

TABLE P-28 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF SURFACE WATER

Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	RECREATIONAL ADULT	RECREATIONAL CHILD
Exposure Time (hrs/day)	2.6	2.6
Surface Water Contact Rate (ml/hr)	50	50
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE P-29 DAILY INTAKE - ADULT
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
 Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	1.60E-04	0.050	48	2.6	25	70	9125	3.908E-08
Antimony, Dissolved	9.00E-06	0.050	48	2.6	25	70	9125	2.198E-09
Bromodichloromethane	2.30E-05	0.050	48	2.6	25	70	9125	5.617E-09
Dibromochloromethane	1.50E-06	0.050	48	2.6	25	70	9125	3.663E-10
Dibenzofuran	5.00E-06	0.050	48	2.6	25	70	9125	1.221E-09
1,4-Dichlorobenzene	2.00E-06	0.050	48	2.6	25	70	9125	4.885E-10
Styrene	6.50E-03	0.050	48	2.6	25	70	9125	1.587E-06
Carbon Tetrachloride	1.00E-05	0.050	48	2.6	25	70	9125	2.442E-09

TABLE P-30 DAILY INTAKE - CHILD
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
 Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	1.60E-04	0.050	48	2.6	15	27	5475	1.013E-07
Antimony, Dissolved	9.00E-06	0.050	48	2.6	15	27	5475	5.699E-09
Bromodichloromethane	2.30E-05	0.050	48	2.6	15	27	5475	1.456E-08
Dibromochloromethane	1.50E-06	0.050	48	2.6	15	27	5475	9.498E-10
Dibenzofuran	5.00E-06	0.050	48	2.6	15	27	5475	3.166E-09
1,4-Dichlorobenzene	2.00E-06	0.050	48	2.6	15	27	5475	1.266E-09
Styrene	6.50E-03	0.050	48	2.6	15	27	5475	4.116E-06
Carbon Tetrachloride	1.00E-05	0.050	48	2.6	15	27	5475	6.332E-09

**TABLE P-31 DAILY INTAKE - ADULT
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO**

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	1.60E-04	0.050	48	2.6	25	70	25550	1.396E-08
Antimony, Dissolved	9.00E-06	0.050	48	2.6	25	70	25550	7.850E-10
Bromodichloromethane	2.30E-05	0.050	48	2.6	25	70	25550	2.006E-09
Dibromochloromethane	1.50E-06	0.050	48	2.6	25	70	25550	1.308E-10
Dibenzofuran	5.00E-06	0.050	48	2.6	25	70	25550	4.361E-10
1,4-Dichlorobenzene	2.00E-06	0.050	48	2.6	25	70	25550	1.744E-10
Styrene	6.50E-03	0.050	48	2.6	25	70	25550	5.670E-07
Carbon Tetrachloride	1.00E-05	0.050	48	2.6	25	70	25550	8.722E-10

**TABLE P-32 DAILY INTAKE - CHILD
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO**

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	1.60E-04	0.050	48	2.6	15	27	25550	2.171E-08
Antimony, Dissolved	9.00E-06	0.050	48	2.6	15	27	25550	1.221E-09
Bromodichloromethane	2.30E-05	0.050	48	2.6	15	27	25550	3.121E-09
Dibromochloromethane	1.50E-06	0.050	48	2.6	15	27	25550	2.035E-10
Dibenzofuran	5.00E-06	0.050	48	2.6	15	27	25550	6.784E-10
1,4-Dichlorobenzene	2.00E-06	0.050	48	2.6	15	27	25550	2.714E-10
Styrene	6.50E-03	0.050	48	2.6	15	27	25550	8.819E-07
Carbon Tetrachloride	1.00E-05	0.050	48	2.6	15	27	25550	1.357E-09

TABLE P-33 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH THUNDERBAY RIVER SURFACE WATER
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	2.6	2.6
Dermal Permeability Constant	0.00084	0.00084
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time	70	70
Carcinogens	25	15
Noncarcinogens		
Conversion Factor	0.001	

TABLE P-34 DAILY INTAKE - ADULT
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/kg-day)
Benzene	1.600E-04	0.1	19400	48	2.6	25	70	9125	0.001	1.516E-06
Antimony, Dissolved	9.000E-06	0.001	19400	48	2.6	25	70	9125	0.001	8.528E-10
Bromodichloromethane	2.300E-05	0.0058	19400	48	2.6	25	70	9125	0.001	1.264E-08
Dibromochloromethane	1.500E-06	0.0039	19400	48	2.6	25	70	9125	0.001	5.543E-10
Dibenzofuran	5.000E-06	0.00084	19400	48	2.6	25	70	9125	0.001	3.980E-10
1,4-Dichlorobenzene	2.000E-06	0.062	19400	48	2.6	25	70	9125	0.001	1.175E-08
Styrene	6.500E-03	0.00084	19400	48	2.6	25	70	9125	0.001	5.174E-07
Carbon Tetrachloride	1.000E-05	0.022	19400	48	2.6	25	70	9125	0.001	2.085E-08

TABLE P-35 DAILY INTAKE - CHILD
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/kg-day)
Benzene	1.600E-04	0.1	13300	48	2.6	15	27	5475	0.001	2.695E-06
Antimony, Dissolved	9.000E-06	0.001	13300	48	2.6	15	27	5475	0.001	1.516E-09
Bromodichloromethane	2.300E-05	0.0058	13300	48	2.6	15	27	5475	0.001	2.247E-08
Dibromochloromethane	1.500E-06	0.0039	13300	48	2.6	15	27	5475	0.001	9.853E-10
Dibenzofuran	5.000E-06	0.00084	13300	48	2.6	15	27	5475	0.001	7.074E-10
1,4-Dichlorobenzene	2.000E-06	0.062	13300	48	2.6	15	27	5475	0.001	2.088E-08
Styrene	6.500E-03	0.00084	13300	48	2.6	15	27	5475	0.001	9.186E-07
Carbon Tetrachloride	1.000E-05	0.022	13300	48	2.6	15	27	5475	0.001	3.708E-08

TABLE P-36 DAILY INTAKE - ADULT
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTG, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	1.600E-04	0.1	19400	48	2.6	25	70	25550	0.001	5.415E-07
Antimony, Dissolved	9.000E-06	0.001	19400	48	2.6	25	70	25550	0.001	3.048E-10
Bromodichloromethane	2.300E-05	0.0058	19400	48	2.6	25	70	25550	0.001	4.515E-09
Dibromochloromethane	1.500E-06	0.0039	19400	48	2.6	25	70	25550	0.001	1.980E-10
Dibenzofuran	5.000E-06	0.00084	19400	48	2.6	25	70	25550	0.001	1.421E-10
1,4-Dichlorobenzene	2.000E-06	0.062	19400	48	2.6	25	70	25550	0.001	4.197E-09
Styrene	6.500E-03	0.00084	19400	48	2.6	25	70	25550	0.001	1.848E-07
Carbon Tetrachloride	1.000E-05	0.022	19400	48	2.6	25	70	25550	0.001	7.445E-09

TABLE P-37 DAILY INTAKE - CHILD
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTG, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	1.600E-04	0.1	13300	48	2.6	15	27	25550	0.001	5.775E-07
Antimony, Dissolved	9.000E-06	0.001	13300	48	2.6	15	27	25550	0.001	3.248E-10
Bromodichloromethane	2.300E-05	0.0058	13300	48	2.6	15	27	25550	0.001	4.815E-09
Dibromochloromethane	1.500E-06	0.0039	13300	48	2.6	15	27	25550	0.001	2.111E-10
Dibenzofuran	5.000E-06	0.00084	13300	48	2.6	15	27	25550	0.001	1.516E-10
1,4-Dichlorobenzene	2.000E-06	0.062	13300	48	2.6	15	27	25550	0.001	4.475E-09
Styrene	6.500E-03	0.00084	13300	48	2.6	15	27	25550	0.001	1.971E-07
Carbon Tetrachloride	1.000E-05	0.022	13300	48	2.6	15	27	25550	0.001	7.940E-09

TABLE P-38 EXPOSURE ASSESSMENT PARAMETERS - SOIL INHALATION
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Inhalation Rate, (mg/cu m)	20
Exposure Time (hours/day)	8
Exposure Frequency (days/year)	250
Exposure Duration (years)	0.08
Body Weight (kilograms)	70
Averaging Time (years)	
Carcinogens	70
Noncarcinogens	0.08

TABLE P-39 DAILY INTAKE - ADULT
SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Concentration (mg/cu m)	Exposure Duration (years)	Inhalation Rate (cu m/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Weight (kg)	Time (days)	Intake Rate (mg/kg-day)
Chlorobenzene	5.166E-02	0.08	20	8	250	70	29.2	8.087E-02
Ethylbenzene	3.912E-02	0.08	20	8	250	70	29.2	6.124E-02
Styrene	3.460E-02	0.08	20	8	250	70	29.2	5.416E-02

TABLE P-40 DAILY INTAKE - ADULT
SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Concentration (mg/cu m)	Exposure Duration (years)	Inhalation Rate (cu m/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Weight (kg)	Time (days)	Intake Rate (mg/kg-day)
Chlorobenzene	5.166E-02	0.08	20	8	250	70	25550	9.243E-05
Ethylbenzene	3.912E-02	0.08	20	8	250	70	25550	6.998E-05
Styrene	3.460E-02	0.08	20	8	250	70	25550	6.190E-05

TABLE P-42 SOIL INHALATION MODEL CALCULATIONS
Site 1, Former POL Facility, Alpena CRTG, Alpena, MI

Soil Density	1.257	g/cm ³	78.46 lb/ft ³
Excavated soil area	5900 ft ²		5400000 cm
Length in wind direction	100 ft		3048 cm
Width across wind direction	50 ft		1524 cm
Total depth of soil	1 ft		30.48 cm
Wind Velocity	353 cm/sec		
Gas Constant	62300 mm Hg-cm ³ /mol-k		
Ambient Temperature	293 K		
Computations			
C(i), mg/kg	3116.31697	Chlorobenzene	
W(i)W, g/g	0.0311631697	3970.36102	Ethylbenzene
W(i), g	6447414.9930688	0.0397036102	3970.36102
W(v,i), g/cm		8214365.0388183	0.0397036102
D(i), cm ² /sec	0.075		8110652.7380074
M(i), g/mol	112.56	0.0658	0.077
p(i) @ 293K, mm Hg	8.75	106.16	104.16
F(V), dimensionless	0.9	7.5	6.25
		0.9	0.9
Initial Values, no soil cap			
E(i,j), g/sec	2.78E+01	2.10E+01	1.86E+01
C(air,i,j), mg/m ³	2.58E-02	1.96E-02	1.73E-02
Time (i,j), hr	2.11E+00	3.56E+00	3.97E+00

TABLE P-43 CANCER ESTIMATE - GROUNDWATER INGESTION SHALLOW AQUIFER PRODUCTION WELL
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects Site 1, Former POL Facility, Alpena CRTS, Alpena, MI									
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Child Chemical- Specific Risk
Benzene	2.249E-06	5.636E-07	NO	0.029	A	Leukemia	IRIS 93	7E-08	2E-08
Antimony, Dissolved	1.166E-05	2.922E-06	NO	NO EVIDENCE				0E+00	0E+00
Bromodichloromethane	7.498E-08	1.879E-08	NO	0.062	B2	Liver	IRIS 93	5E-09	1E-09
Dibromodichloromethane	2.166E-07	5.427E-08	NO	NO EVIDENCE				0E+00	0E+00
Dibenzofuran	4.166E-08	1.044E-08	NO	NO EVIDENCE	C	Liver tumors	HEAST FY93	0E+00	8E-11
1,4-Dichlorobenzene	1.250E-08	3.131E-09	NO	0.024				3E-10	0E+00
Styrene	2.166E-08	5.427E-09	NO	NO EVIDENCE	B2	Heptocellular carcinomas		0E+00	0E+00
Carbon Tetrachloride	9.997E-06	2.505E-06	NO	0.13				1E-06	3E-07
Total									

TABLE P-44 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INGESTION SHALLOW AQUIFER PRODUCTION WELL
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects

Site 1, Former POL Facility, Alpena CRTIC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Benzene	6.298E-06	2.630E-06	NO	NO DATA	NA	NA	NA	8E-02		3E-02	
Atrimony, Dissolved	3.266E-05	1.364E-05	NO	0.0004	Reduced lifespan	IRIS 93		1E-05		4E-06	
Bromodichloromethane	2.099E-07	8.767E-08	NO	0.02	Renal cyomegaly	IRIS 93	1	6E-06		1E-05	
Dibromochloromethane	1.166E-07	2.533E-07	NO	0.02	Hepatic lesions	IRIS 93					
Dibenzoluran	1.166E-07	4.871E-08	NO	NO DATA	NA	NA	NA				
1,4-Dichlorobenzene	3.499E-08	1.461E-08	NO	NO DATA	NA	NA	NA				
Styrene	6.065E-08	2.533E-08	NO	0.2	Hepatotoxicity	IRIS 93	1	3E-07		1E-07	
Carbon Tetrachloride	2.799E-05	1.169E-05	NO	0.0007	Liver Lesions	IRIS 93	1	4E-02		2E-02	
Total									1E-01		5E-02

TABLE P-46 CANCER ESTIMATE - GROUNDWATER INHALATION SHALLOW AQUIFER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects

Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Childen Chemical- Specific Risk	Total Pathway Risk
Benzene	7.649E-07	1.917E-07	NO	0.029	A	Leukemia	IRIS, 1993	2E-08	6E-09	
Artimony, Dissolved	0.000E+00	0.000E+00	NO	NO EVIDENCE			IRIS, 1993	0E+00	0E+00	
Bromodichloromethane	2.550E-08	6.389E-09	NO	0.062	B2	NA (1)	IRIS, 1993	2E-09	4E-10	
Dibromochloromethane	7.366E-08	1.846E-08	NO	0.084	C	NA (1)	IRIS, 1993	6E-09	2E-09	
Dibenzoluran	0.000E+00	0.000E+00	NO	NO DATA			IRIS, 1993	0E+00	0E+00	
1,4-Dichlorobenzene	4.250E-09	1.065E-09	NO	0.04	C	NA	IRIS, 1993	2E-10	4E-11	
Styrene	7.366E-09	1.846E-09	NO	NO EVIDENCE			IRIS, 1993	0E+00	0E+00	
Carbon Tetrachloride	3.400E-06	8.518E-07	NO	0.053	B2	Cardiomyopathy (rat, mouse, hamster)	IRIS, 1993	2E-07	5E-08	2E-07

(1) Oral slope factor was used

TABLE P-48 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INHALATION SHALLOW AQUIFER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects

Site 1, Former POL Facility, Alpena CRTG, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Benzene	2.142E-06	8.944E-07	NO	NO DATA	NA	IRIS, chronic oral RfD used	NA	0E+00		0E+00	
Antimony, Dissolved	0.000E+00	0.000E+00	NO	0.0004	NA	IRIS, chronic oral RfD used	NA	4E-06		1E-06	
Bromodichloromethane	7.139E-08	2.981E-08	NO	0.02	NA	IRIS, chronic oral RfD used	NA	1E-05		4E-06	
Dibromochloromethane	2.062E-07	8.613E-08	NO	0.02	NA	IRIS, chronic oral RfD used	NA	6E-08		2E-08	
Dibenzofuran	0.000E+00	0.000E+00	NO	0.2	Liver, Kidney	HEAST 93	NA	2E-08		9E-09	
1,4-Dichlorobenzene	1.190E-08	4.969E-09	NO	1	NA	IRIS, chronic oral RfD used	NA	1E-02		6E-03	
Styrene	2.062E-08	8.613E-09	NO	0.0007	NA	IRIS, chronic oral RfD used	NA				
Carbon Tetrachloride	9.519E-06	3.975E-06	NO								
Total									1E-02		6E-03

TABLE P-47 CANCER ESTIMATE - DERMAL CONTACT WITH GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects

Site 1, Former POL Facility, Alpena CRTG, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Total Pathway Risk	Child Chemical- Specific Risk	Total Pathway Risk
Benzene	5.455E-07	9.370E-08	YES	2.90E-02	A	Leukemia	IRIS 93	2E-08		3E-09	
Antimony, Dissolved	2.828E-08	4.858E-09	YES	NO EVIDENCE				0E+00		0E+00	
Bromodichloromethane	1.055E-09	1.812E-10	YES	6.33E-02	B2	Liver	IRIS 93	7E-11		1E-11	
Dibromochloromethane	2.049E-09	3.519E-10	YES	NO EVIDENCE				0E+00		0E+00	
Dibenzofuran	8.485E-11	1.459E-11	YES	NO EVIDENCE				0E+00		0E+00	
1,4-Dichlorobenzene	1.879E-09	3.227E-10	YES	2.40E-02	C	Liver tumors	HEAST FY93	5E-11		8E-12	
Styrene	4.412E-11	7.579E-12	YES	NO EVIDENCE				0E+00		0E+00	
Carbon Tetrachloride	5.334E-07	9.162E-08	YES	1.30E-01	B2	Hepatocellular carcinomas		7E-08	9E-08	1E-08	1E-08
Total											

*Adjusted from administered to absorbed dose using an oral absorption efficiency factor. Benzene = 1, Bromodichloromethane = 0.98, 1,4 DCB=1, CO4=0.05.

**TABLE P-48 CHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN**

Noncarcinogenic Effects

Site 1, Former POL Facility, Alpena CRTIC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Child Chemical- Specific Risk	Total Pathway Risk
Benzene	1.527E-06	4.373E-07	YES	NO DATA	NA	NA	NA	4E-03		1E-03	
Antimony, Dissolved	7.919E-08	2.267E-08	YES	2E-05	Reduced lifespan	IRIS 93		2E-07		4E-08	
Bromochloromethane	2.953E-09	8.454E-10	YES	0.0195	Renal cyromegaly	IRIS 93	1	3E-07		8E-08	
Dibromochloromethane	3.736E-09	1.642E-09	YES	0.02	Hepatic lesions	NA					
Dibenzotran	2.376E-10	6.802E-11	YES	NO DATA	NA	NA	NA				
1,4-Dichlorobenzene	5.261E-09	1.506E-09	YES	NO DATA	NA	NA	NA				
Styrene	1.235E-10	3.537E-11	YES	0.01	Hepatotoxicity	IRIS 93	1	1E-08		4E-09	
Carbon Tetrachloride	1.493E-06	4.275E-07	YES	3.5E-05	Liver Lesions	IRIS 93	1	4E-02	5E-02	1E-02	1E-02
Total											

**TABLE P-49 CANCER ESTIMATE - DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - ADULTS**

Carcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	Adjusted for Absorption	CDI	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Chemical- Specific Risk	Total Pathway Risk
Chlorobenzene	7.529E-08	YES	YES	NO EVIDENCE				0E+00	
Ethylbenzene	9.593E-08	YES	YES	NO EVIDENCE				0E+00	
Styrene	9.472E-08	YES	YES	NO EVIDENCE*				0E+00	
Total									0E+00

*Styrene classified as possible human carcinogen by IRAC. No slope factor has been adopted as of 12/08/93.

**TABLE P-60 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - ADULTS**

Noncarcinogenic Effects

Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Excavation		CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Chemical- Specific Risk	Total Pathway Risk
	CDI Worker (mg/kg-day)	CDI Excavation (mg/kg-day)							
Chlorobenzene	6.588E-05		YES	0.01	Liver	HEAST FY93	1	7E-03	
Ethylbenzene	8.394E-05		YES	0.085	Liver and Kidney	HEAST FY93	1	1E-03	
Styrene	8.288E-05		YES	0.01	Liver	IRIS 93	1	8E-03	
Total									2E-02

*RfD adjusted from administered to absorbed dose using an absorption efficiency of 5%, unless a chemical specific efficiency was available. Ethylbenzene 85% efficiency used.

TABLE P-51 CANCER ESTIMATE - SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Carcinogenic Effects

Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker		CDI Adjusted for Absorption	SF (mg/kg-day) ⁽¹⁾	Weight of Evidence	Type of Cancer	SF Source	Chemical-Specific Risk	Total Pathway Risk
	CDI (mg/kg-day)	NO							
Chlorobenzene	1.673E-05	NO	NO EVIDENCE	NO EVIDENCE				0E+00	
Ethylbenzene	2.131E-05	NO	NO EVIDENCE	NO EVIDENCE				0E+00	
Styrene	2.104E-05	NO	NO EVIDENCE(1)	NO EVIDENCE(1)				0E+00	
Total									0E+00

(1) Classified by IRAC as possible human carcinogen. No SF has been adopted as of 12/03/93.

TABLE P-52 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Chemical- Specific Risk	Total Pathway Risk
Chlorobenzene	1.67E-05	NO	0.2	Liver	HEAST FY93	1	8E-05	
Ethylbenzene	2.13E-05	NO	1	Liver and Kidney	HEAST FY93	1	2E-05	
Styrene	2.10E-05	NO	0.2	Red Blood Cell, Liver	IRIS 93	1	1E-04	
Total								2E-04

No subchronic RfD available as of 12/08/93. Chronic RfD used.

TABLE P-53. CANCER ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects Site 1, Former POL Facility, Alpena CRTC, Alpena, MI											
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	CDI for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Children Chemical- Specific Risk	Total Pathway Risk
Benzene	3.77E-08	4.87E-08	NO	NO	0.029	A	Leukemia	IRIS 93	0E+00	1E-09	1E-09
Aroclor, Dissolved	8.83E-11	1.09E-10	NO	NO	NO EVIDENCE				0E+00	0E+00	0E+00
Bromodichloromethane	6.77E-09	8.39E-09	NO	NO	0.062	B2	Liver	IRIS 93	0E+00	4E-10	5E-10
Dibromochloromethane	3.39E-10	4.19E-10	NO	NO	NO EVIDENCE				0E+00	0E+00	0E+00
Dibenzoturan	4.91E-11	6.08E-11	NO	NO	NO EVIDENCE				0E+00	0E+00	0E+00
1,4-Dichlorobenzene	1.18E-09	1.46E-09	NO	NO	0.024	C	Liver tumors	HEAST FY83	0E+00	3E-11	4E-11
Styrene	6.38E-06	7.90E-06	NO	NO	NO EVIDENCE		Heptocellular carcinomas		0E+00	0E+00	0E+00
Carbon Tetrachloride	9.81E-11	1.22E-10	NO	NO	0.13	B2			1E-11	2E-11	2E-11
Total									2E-09		2E-09

TABLE P-54 CHRONIC HAZARDOUS INDEX ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Benzene	1.06E-07	2.18E-07	NO	NO DATA	NA	NA	NA	8E-07		1E-08	
Arlimony Dissolved	2.47E-10	5.11E-10	NO	0.0004	Reduced lifespan	IRIS 93	1	9E-07		2E-08	
Bromodichloromethane	1.90E-08	3.91E-08	NO	0.02	Renal cyromegaly	IRIS 93	1	5E-08		1E-07	
Dibromochloromethane	9.48E-10	1.96E-09	NO	0.02	Hepatic lesions	NA	NA				
Dibenzofuran	1.37E-10	2.84E-10	NO	NO DATA	NA	NA	NA				
1,4-Dichlorobenzene	3.30E-09	6.81E-09	NO	NO DATA	NA	NA	NA				
Styrene	1.79E-05	3.69E-05	NO	0.2	Hepatotoxicity	IRIS 93	1	9E-05		2E-04	
Carbon Tetrachloride	2.75E-10	5.67E-10	NO	0.0007	Liver Lesions	IRIS 93	1	4E-07		8E-07	
Total									8E-05		2E-04

TABLE P-66 CANCER ESTIMATE - SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Cardiogenic Effects

Site 1, Former POL Facility, Alpena CRTS, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Benzene	1.39E-08	2.171E-08	NO	0.029	A	Leukemia	IRIS 93	0E+00		0E+00	
Artimony, Dissolved	7.85E-10	1.221E-09	NO	NO EVIDENCE				4E-10		6E-10	
Bromodichloromethane	2.00E-09	3.121E-09	NO	0.062	B2	Liver	IRIS 93	0E+00		0E+00	
Dibromodichloromethane	1.30E-10	2.03E-10	NO	NO EVIDENCE				1E-10		2E-10	
Dibenzofuran	4.361E-10	6.784E-10	NO	NO EVIDENCE				0E+00		0E+00	
1,4-Dichlorobenzene	1.74E-10	2.714E-10	NO	0.024	C	Liver tumors	HEAST FY93	0E+00		7E-12	
Styrene	5.670E-07	8.819E-07	NO	NO EVIDENCE				4E-12		0E+00	
Carbon Tetrachloride	8.722E-10	1.357E-09	NO	0.13	B2	Hepatocellular carcinomas		0E+00		0E+00	
Total								1E-10	6E-10	2E-10	1E-09

**TABLE P-68 CHRONIC HAZARDOUS INDEX ESTIMATE - SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN**

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTIC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	CDI	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Benzene	3.908E-08	1.013E-07	NO	NO	NO DATA	NA	NA	NA	5E-06		1E-05	
Antimony, Dissolved	2.198E-09	5.699E-09	NO	NO	0.0004	Reduced lifespan	IRIS 93	1	3E-07		7E-07	
Bromodichloromethane	5.617E-09	1.456E-08	NO	NO	0.02	Renal cytomegaly	IRIS 93	1	2E-08		5E-08	
Dibromodichloromethane	3.663E-10	9.498E-10	NO	NO	0.02	Hepatic lesions	IRIS 93	1	NA		NA	
Dibenzofuran	1.221E-09	3.168E-09	NO	NO	NO DATA	NA	NA	NA	NA		NA	
1,4-Dichlorobenzene	4.885E-10	1.286E-09	NO	NO	NO DATA	NA	NA	1	8E-06		2E-05	
Styrene	1.587E-06	4.116E-06	NO	NO	0.2	Hepatotoxicity	IRIS 93	1	3E-06		9E-06	
Carbon Tetrachloride	2.442E-09	6.332E-09	NO	NO	0.0007	Liver Lesions	IRIS 93	1		2E-05		4E-05
Total												

TABLE P-67 CANCER ESTIMATE - SURFACE WATER, DERMAL
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Cardiogenic Effects

Site 1, Former POL Facility, Alpers CRTG, Alpers, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF* (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Benzene	5.41E-07	5.77E-07	YES	2.90E-02	A	Leukemia	IRIS 93	0E+00	2E-08	0E+00	2E-08
Antimony, Dissolved	3.05E-10	3.25E-10	YES	NO EVIDENCE				0E+00	0E+00	0E+00	0E+00
Bromodichloromethane	4.51E-09	4.81E-09	YES	6.33E-02	B2	Liver	IRIS 93	3E-10	3E-10	3E-10	3E-10
Chlorodibromomethane	1.98E-10	2.11E-10	YES	NO EVIDENCE				0E+00	0E+00	0E+00	0E+00
Dibenzofuran	1.42E-10	1.52E-10	YES	NO EVIDENCE				0E+00	0E+00	0E+00	0E+00
1,4-Dichlorobenzene	4.20E-09	4.48E-09	YES	2.40E-02	C	Liver tumors	HEAST FY93	1E-10	1E-10	1E-10	1E-10
Styrene	1.85E-07	1.97E-07	YES	NO EVIDENCE				0E+00	0E+00	0E+00	0E+00
Carbon Tetrachloride	7.45E-09	7.94E-09	YES	1.30E-01	B2	Hepatocellular carcinomas		1E-09	1E-09	1E-09	1E-09
Total									2E-08		2E-08

*Adjusted from administered to absorbed dose using an oral absorption efficiency factor. Benzene = 1, Bromodichloromethane = 0.98, 1,4 DCB = 1, CCl4 = 0.5.

TABLE P-68 CHRONIC HAZARDOUS INDEX ESTIMATE - SURFACE WATER DERMAL
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRIC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Benzene	1.52E-08	2.69E-06	YES	NO DATA	NA	NA	NA				
Antimony, Dissolved	8.53E-10	1.52E-09	YES	2E-05	Reduced lifespan	IRIS 93	1	4E-05		8E-05	
Bromochloromethane	1.26E-08	2.29E-08	YES	0.0196	Renal cytomegaly	IRIS 93	1	6E-07		1E-06	
Dibromochloromethane	5.54E-10	9.89E-10	YES	0.02	Hepatic lesions	IRIS 93	1	3E-08		5E-08	
Dibenzofuran	3.98E-10	7.07E-10	YES	NO DATA	NA	NA	NA				
1,4-Dichlorobenzene	1.18E-08	2.09E-08	YES	NO DATA	NA	NA	NA				
Styrene	5.17E-07	9.20E-07	YES	0.01	Hepatotoxicity	IRIS 93	1	5E-05		9E-05	
Carbon Tetrachloride	2.08E-08	3.71E-08	YES	3.5E-05	Liver Lesions	IRIS 93	1	6E-04		1E-03	
Total									7E-04		1E-03

TABLE P-59 CANCER ESTIMATE - SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Carcinogenic Effects Site 1, Former POL Facility, Alpena CRTC, Alpena, MI									
Chemical	Adult CDI (mg/kg-day)	CDI Adjusted for Absorption	CDI (mg/kg-day) ⁻¹	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Excavation Worker Chemical- Specific Risk	Total Pathway Risk
Chlorobenzene	9.243E-05	NO	NO	NO EVIDENCE				0E+00	
Ethylbenzene	6.998E-05	NO	NO	NO EVIDENCE*				0E+00	
Styrene	6.190E-05	NO	NO	NO EVIDENCE*				0E+00	
Total									0E+00

* Styrene classified as possible human carcinogen by IRAC. No slope factor has been adopted as of 12/08/93.

TABLE P-60 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Excavation Worker Chemical- Specific Risk	Total Pathway Risk
Chlorobenzene	8.087E-02	NO	0.05	Liver and Kidney	Heast FY93	1	2E+00	
Ethylbenzene	6.124E-02		0.29	Developmental Toxicity	Heast FY93	1	2E-01	
Styrene	5.416E-02		0.91	CNS effects	Heast FY93	1	6E-02	
Total								2E+00

* RfD converted from corresponding RfC values.

Groundwater Solute Transport Model Data - Site 1

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.
2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.
3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.
4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer-properties.
5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.
6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft²/day at TF4-MW3 to 15,290 ft²/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^n (h_m - h_s)^2]^{0.5}$$

n = number of wells

h_m = measured head

h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22 -	676.29	675.78	0.51
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = $128.78/38 = 3.3891$
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

- * The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).
- * The initial head data input to the transport model are results of measurements taken in September 1993.
- * Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.
- * Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.
- * The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.
- * The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 1

The following compounds were present at Site 1: Benzene, Bromodichloromethane, Dibromochloromethane, 1,4- Dichlorobenzene, Styrene, Antimony, Carbon Tetrachloride, and Dibenzofuran. Concentrations input to the model are the result of groundwater sampling conducted during the July to September 1993 RI field events.

For Site 1, several scenarios were modeled. These included monitoring chemical concentrations through time along the South Branch of the Thunder Bay River and at Production Well #3 for chemicals observed in several wells at Site 1. Wells S1MW14, S1MW11, S1MW6, and Production Well #3 all had chemicals present above MDNR Type A or B cleanup criteria.

The following scenarios were modeled for S1MW14: Benzene at 11.5 ug/l, Bromodichloromethane at 0.78 ug/l, Dibromochloromethane at 2.1 ug/l, 1,4 - Dichlorobenzene at 0.08 ug/l, and Styrene at a concentration of 0.13 ug/l. Concentrations were input to the node corresponding to S1MW14 and concentrations through time were monitored along the South Branch of the Thunder Bay River.

Wells S1MW11 and S1MW6 contained elevated levels of Antimony at a concentration of 39.2 ug/l. This concentration was input to the model and the corresponding concentrations of Antimony through time were monitored along the South Branch of the Thunder Bay River.

Additionally, Carbon Tetrachloride and Dibenzofuran were present in Production Well #3 at concentrations of 1.2 ug/l and 2.5 ug/l, respectively. These values were input to the model and the concentrations were monitored through time along the South Branch of the Thunder Bay River.

Appendix Q: Site 2 Risk Assessment

Table Q-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 2
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-MP2	MW1	PC-MP2-MW1-GW4	GROUNDWATER	Arsenic, Dissolved	7.2000
PC-MP2	MW3	PC-MP2-MW3-GW4	GROUNDWATER	Arsenic, Dissolved	2.0000
PC-MP2	MW4	PC-MP2-MW4-GW4	GROUNDWATER	Arsenic, Dissolved	2.0000
PC-MP2	MW5	PC-MP2-MW5-GW4	GROUNDWATER	Arsenic, Dissolved	5.0500
PC-MP2	MW6	PC-MP2-MW6-GW4	GROUNDWATER	Arsenic, Dissolved	2.0000
PC-MP2	MW7	PC-MP2-MW7-GW4	GROUNDWATER	Arsenic, Dissolved	2.0000
PC-MP2	MW1	PC-MP2-MW1-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-MP2	MW2	PC-MP2-MW2-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-MP2	MW3	PC-MP2-MW3-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-MP2	MW4	PC-MP2-MW4-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-MP2	MW5	PC-MP2-MW5-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-MP2	MW6	PC-MP2-MW6-GW4	GROUNDWATER	Tetrachloroethylene	0.1200
PC-MP2	MW7	PC-MP2-MW7-GW4	GROUNDWATER	Tetrachloroethylene	6.3000

Table Q-2A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Soil - Site 2
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE	RESULT
PC-MP2	SB10	PC-MP2-SB10-SS00-01	SOIL	Lead	0.0000 1.0000	1.3000
PC-MP2	SB6	PC-MP2-SB6-SS00-02	SOIL	Lead	0.0000 2.0000	31.0000

TABLE Q-1 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF GROUNDWATER
Site 2, Motor Pool, Alpena CRTG, Alpena, MI

PARAMETER	ADULT	CHILD
Ingestion Rate (L/day)	2	2
Exposure Frequency (days/year)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE Q-2 DAILY INTAKE - ADULT
INGESTION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTIC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	4.613E-03	2	298	25	70	9125	1.076E-04
Tetrachloroethylene	2.737E-03	2	298	25	70	9125	6.384E-05

TABLE Q-3 DAILY INTAKE - CHILD
INGESTION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTIC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	4.613E-03	2	48	15	27	5475	4.494E-05
Tetrachloroethylene	2.737E-03	2	48	15	27	5475	2.666E-05

TABLE Q-4 DAILY INTAKE - ADULT
INGESTION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRIC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	4.613E-03	2	298	25	70	25550	3.843E-05
Tetrachloroethylene	2.737E-03	2	298	25	70	25550	2.280E-05

TABLE Q-5 DAILY INTAKE - CHILD
INGESTION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRIC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	4.613E-03	2	48	15	27	25550	9.629E-06
Tetrachloroethylene	2.737E-03	2	48	15	27	25550	5.712E-06

TABLE Q-6 DAILY INTAKE - ADULT
INGESTION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTG, Alpena MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	9.000E-04	2	298	25	70	9125	2.099E-05
Tetrachloroethylene	1.000E-05	2	298	25	70	9125	2.333E-07

TABLE Q-7 DAILY INTAKE - CHILD
INGESTION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTG, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	9.000E-04	2	48	15	27	5475	8.767E-06
Tetrachloroethylene	1.000E-05	2	48	15	27	5475	9.741E-08

TABLE Q-8 DAILY INTAKE - ADULT
INGESTION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	9.000E-04	2	298	25	70	25550	7.498E-06
Tetrachloroethylene	1.000E-05	2	298	25	70	25550	8.331E-08

TABLE Q-9 DAILY INTAKE - CHILD
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	9.000E-04	2	48	15	27	25550	1.879E-06
Tetrachloroethylene	1.000E-05	2	48	15	27	25550	2.087E-08

TABLE Q-10 EXPOSURE ASSESSMENT PARAMETERS - INHALATION OF GROUNDWATER
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Exposure Time (hours/day)	0.12	0.12
Inhalation Rate (cu m/hr)	0.6	0.6
Exposure Frequency (days/yr)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE Q-11 DAILY INTAKE - ADULT
 INHALATION OF SHALLOW GROUNDWATER
 FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
 Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0.000E+00	0.6	298	0.12	25	70	9125	0.000E+00
Tetrachloroethylene	2.585E-02	0.6	298	0.12	25	70	9125	2.171E-05

TABLE Q-12 DAILY INTAKE - CHILD
 INHALATION OF SHALLOW GROUNDWATER
 FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
 Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0.000E+00	0.600	48	0.12	15	27	5475	0.000E+00
Tetrachloroethylene	2.585E-02	0.600	48	0.12	15	27	5475	9.065E-06

TABLE Q-13 DAILY INTAKE - ADULT
INHALATION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/kg-day)
Arsenic, Dissolved	0.000E+00	0.6	298	0.12	25	70	25550	0.000E+00
Tetrachloroethylene	2.585E-02	0.6	298	0.12	25	70	25550	7.753E-06

TABLE Q-14 DAILY INTAKE - CHILD
INHALATION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/kg-day)
Arsenic, Dissolved	0.000E+00	0.600	48	0.12	15	27	25550	0.000E+00
Tetrachloroethylene	2.585E-02	0.600	48	0.12	15	27	25550	1.943E-06

TABLE Q-15 DAILY INTAKE - ADULT
INHALATION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0.000E+00	0.6	298	0.12	25	70	9125	0.000E+00
Tetrachloroethylene	9.446E-05	0.6	298	0.12	25	70	9125	7.932E-08

TABLE Q-16 DAILY INTAKE - CHILD
INHALATION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0	0.600	48	0.12	15	27	5475	0.000E+00
Tetrachloroethylene	9.446023E-05	0.600	48	0.12	15	27	5475	3.313E-08

TABLE Q-17 DAILY INTAKE - ADULT
 INHALATION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
 FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
 Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0.000E+00	0.6	298	0.12	25	70	25550	0.000E+00
Tetrachloroethylene	9.446E-05	0.6	298	0.12	25	70	25550	2.833E-08

TABLE Q-18 DAILY INTAKE - CHILD
 INHALATION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
 FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
 Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0.000E+00	0.600	48	0.12	15	27	25550	0.000E+00
Tetrachloroethylene	9.446E-05	0.600	48	0.12	15	27	25550	7.098E-09

TABLE Q-19 GROUNDWATER INHALATION MODEL CALCULATIONS
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemicals	Chemical Concentration (mg/L)	Fraction Volatilized (unitless)	Water Flow Rate (L/hr)	Showering Duration Period (hr)	Post Showering Duration Period (hr)	Bathroom Volume (cu m)	Showering Maximum Contaminant Concn'n in Air (mg/cu m)	During and After Showering MAX Contaminant Concn'n in Air (mg/cu m)
Arsenic, Dissolved	0.000E+00	0.7	750	0.25	0.35	11	0.000E+00	0.000E+00
Tetrachloroethylene	2.737E-03	0.7	750	0.25	0.35	11	3.265E-02	2.585E-02
Future land-use - Deep Aquifer								
Arsenic, Dissolved	0.000E+00	0.7	750	0.25	0.35	11	0.000E+00	0.000E+00
Tetrachloroethylene	1.000E-05	0.7	750	0.25	0.35	11	1.193E-04	9.446E-05

TABLE Q-20 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH GROUNDWATER
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	0.25	0.25
Dermal Permeability Constant	*	*
Exposure Frequency (days/year)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	

* Chemical Specific Dermal Permeability Constant

TABLE Q-21 DAILY INTAKE - ADULT
SHALLOW GROUNDWATER DERMAL CONTACT
CURRENT LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTIC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(a) 4.613E-03	0.003	19400	298	0.25	25	70	9125	0.001	7.828E-07
Tetrachloroethylene	(b) 2.737E-03	0.4	19400	298	0.25	25	70	9125	0.001	6.192E-05

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).

(b) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

TABLE Q-22 DAILY INTAKE - CHILD
SHALLOW GROUNDWATER DERMAL CONTACT
CURRENT LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTIC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(a) 4.613E-03	0.003	13300	48	0.25	15	27	5475	0.001	2.241E-07
Tetrachloroethylene	(b) 2.737E-03	0.4	13300	48	0.25	15	27	5475	0.001	1.773E-05

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).

(b) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

TABLE Q-23 DAILY INTAKE - ADULT
SHALLOW GROUNDWATER DERMAL CONTACT
CURRENT LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/kg-day)
Arsenic, Dissolved	(a) 4.613E-03	0.003	19400	298	0.25	25	70	25550	0.001	2.796E-07
Tetrachloroethylene	(b) 2.737E-03	0.4	19400	298	0.25	25	70	25550	0.001	2.211E-05

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(b) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

TABLE Q-24 DAILY INTAKE - CHILD
SHALLOW GROUNDWATER DERMAL CONTACT
CURRENT LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/kg-day)
Arsenic, Dissolved	(a) 4.613E-03	0.003	13300	48	0.25	15	27	25550	0.001	4.803E-08
Tetrachloroethylene	(b) 2.737E-03	0.4	13300	48	0.25	15	27	25550	0.001	3.789E-06

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(b) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

TABLE Q-25 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(c) 9.000E-04	0.001	19400	298	0.25	25	70	9125	0.001	5.091E-08
Tetrachloroethylene	(a) 1.000E-05	0.4	19400	298	0.25	25	70	9125	0.001	2.263E-07

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Tables 5-3 of U. S. EPA, 1992a).

TABLE Q-26 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(c) 9.000E-04	0.001	13300	48	0.25	15	27	5475	0.001	1.458E-08
Tetrachloroethylene	(a) 1.000E-05	0.4	13300	48	0.25	15	27	5475	0.001	6.478E-08

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Tables 5-3 of U. S. EPA, 1992a).

TABLE Q-27 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(c) 9.000E-04	0.001	19400	298	0.25	25	70	25550	0.001	1.818E-08
Tetrachloroethylene	(a) 1.000E-05	0.4	19400	298	0.25	25	70	25550	0.001	8.081E-08

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Tables 5-3 of U. S. EPA, 1992a).

TABLE Q-28 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(c) 9.000E-04	0.001	13300	48	0.25	15	27	25550	0.001	3.123E-09
Tetrachloroethylene	(a) 1.000E-05	0.4	13300	48	0.25	15	27	25550	0.001	1.388E-08

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Tables 5-3 of U. S. EPA, 1992a).

TABLE Q-29. CANCER ESTIMATE - SHALLOW GROUNDWATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Cardiogenic Effects

Site 2, Motor Pool, Alpena CRIC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Arsenic, Dissolved	3.84E-05	9.82E-06	NO	1.8	A (1)	Skin, Lung	IRIS, 93	7E-05		2E-05	
Tetrachloroethylene	2.20E-05	5.71E-06	NO	0.051	B2 (2)	Liver	CA EPA	1E-06		3E-07	
Total									7E-05		2E-05

1) Converted from a unit risk of 10-05 ug/L given in IRIS.

2) Retrieved from California EPA, 1992b.

TABLE Q-30. CHRONIC HAZARDOUS INDEX ESTIMATE - SHALLOW GROUNDWATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects

Site 2, Motor Pool, Alpena, CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Arsenic, Dissolved	1.07E-04	4.49E-05	NO	0.003	Keratosis	IRIS, 93	1	4E-01		1E-01	
Tetrachloroethylene	6.38E-05	2.66E-05	NO	0.01	Hepatotoxicity	IRIS, 93	1	8E-03		3E-03	
Total									4E-01		2E-01

TABLE Q-31. CANCER ESTIMATE - GROUNDWATER INGESTION DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects Site 2, Motor Pool, Alpena CRTS, Alpena, MI									
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Children Chemical- Specific Risk
Arsenic, Dissolved	7.49E-06	1.07E-06	NO	1.8	A (1)	Skin, Lung	IRIS 93	1E-05	3E-06
Tetrachloroethylene	8.33E-06	2.08E-06	NO	0.051	B2 (2)	Liver	CA EPA	4E-09	1E-09
Total								1E-05	3E-06

1) Converted from a unit risk of 10-05 ug/L given in IRIS.

2) Retrieved from California EPA, 1992b.

TABLE Q-32 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INGESTION DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects

Site 2, Motor Pool, Alpena CRT, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RID (mg/kg-day)	Critical Effect	RID Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Arsenic, Dissolved	2.089E-05	8.767E-06	NO	0.0003	Keratosis	IRIS, 93	1	7E-02		3E-02	
Tetrachloroethylene	2.333E-07	9.741E-08	NO	0.01	Hepatotoxicity	IRIS, 93	1	2E-05		1E-05	
Total									7E-02		3E-02

TABLE Q-33 CANCER ESTIMATE - SHALLOW GROUNDWATER INHALATION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Cardiogenic Effects Site 2, Motor Pool, Alpena CRTS, Alpena, MI									
Chemical	Adult CDI (mg/kg-day) 0.000E+00	Child CDI (mg/kg-day) 0.000E+00	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹ 15	Weight of Evidence A (1) B2 (2)	Type of Cancer Lung, skin Leukemia	SF Source IRIS 93 CA EPA	Adult Chemical- Specific Risk 0E+00 1E-08	Child Chemical- Specific Risk 0E+00 3E-09
Arsenic Dissolved	7.753E-06	1.943E-06	NO	0.0018					
Tetrachloroethylene			NO						
Total								1E-08	3E-09

- 1) Inhalation slope factor converted from inhalation unit risk.
2) Retrieved from California EPA, 1992.

TABLE Q-34 CHRONIC HAZARDOUS INDEX ESTIMATE - SHALLOW GROUNDWATER INHALATION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 2, Motor Pool, Alpena CRTG, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Children Chemical- Specific Risk	Total Pathway Risk
Arsenic, Dissolved	0.000E+00	0.000E+00	NO	0.0003	NA	IRIS, 93	NA	0E+00	0E+00	
Tetrachloroethylene	2.171E-05	9.065E-06	NO	0.01	NA	IRIS, 93	NA	2E-03	9E-04	
Total										2E-03 9E-04

TABLE Q-36 CANCER ESTIMATE - GROUNDWATER INHALATION DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Cardiogenic Effects Site 2, Motor Pool, Alpena CRIC, Alpena, MI									
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Child Chemical- Specific Risk
Arsenic, Dissolved	0.000E+00	0.000E+00	NO	15	A (1)	Lung, skin	IRIS 93	0E+00	0E+00
Tetrachloroethylene	2.033E-08	7.098E-09	NO	0.0018	B2 (2)	Leukemia	CA EPA	5E-11	1E-11
Total								5E-11	1E-11

1) Inhalation slope factor converted from inhalation unit risk.

2) Retrieved from California EPA, 1992.

TABLE Q-38 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INHALATION DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncardiogenic Effects Site 2, Motor Pool, Alpena CRTIC, Alpena, MI										
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Children Chemical- Specific Risk	Total Pathway Risk
Arsenic, Dissolved	0.000E+00	0.000E+00	NO	0.0003	NA	IRIS, 93	NA	0E+00	0E+00	
Tetrachloroethylene	7.932E-08	3.313E-08	NO	0.01	NA	IRIS, 93	NA	8E-06	3E-06	8E-06
Total										3E-06

TABLE Q-37 CANCER ESTIMATE - DERMAL CONTACT WITH SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects Site 2, Motor Pool, Alpena, CRTG, Alpena, MI										
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	CDI Adjusted for Absorption	SF* (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Child Chemical- Specific Risk
Arsenic, Dissolved	2.796E-07	4.803E-08	NA	NA	1.9	A	NA	IRIS, 93 CA EPA	5E-07	9E-08
Tetrachloroethylene	2.211E-05	3.799E-06	NA	NA	0.051	B2	NA		1E-06	2E-07
									2E-06	3E-07

* Adjusted from administered to absorbed dose using an absorption efficiency of As0.95 (ATSDR, 90), PCE 1.0 (ATSDR,90)

TABLE Q-38 CHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects

Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Child Chemical- Specific Risk	Total Pathway Risk
Arsenic, Dissolved	7.828E-07	2.241E-07	YES	0.0003	NA	IRIS, 93	1	3E-03		7E-04	
Tetrachloroethylene	6.192E-05	1.773E-05	YES	0.01	NA	IRIS, 93	1	6E-03		2E-03	
									9E-03		3E-03

* Adjusted from administered to absorbed dose using an absorption efficiency of As0.95 (ATSDR, 90), PCE 1.0 (ATSDR,90)

TABLE Q-39 CANCER ESTIMATE - DERMAL CONTACT WITH GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects Site 2, Motor Pool, Alpena CRTC, Alpena, MI										
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	CDI (mg/kg-day) ^a	SF *	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Child Chemical- Specific Risk
Arsenic, Dissolved	1.81E-08	3.123E-09	NA	NA	1.9	A	NA	IRIS, 93	3E-08	6E-09
Tetrachloroethylene	8.081E-08	1.388E-08	NA	NA	0.051	B2	NA	CA EPA	4E-09	7E-10
Total									4E-08	7E-09

* Adjusted from administered to absorbed dose using an absorption efficiency of As0.95 (ATSDR, 90), PCE 1.0 (ATSDR, 90)

TABLE Q-40 CHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	CDI YES	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Child Chemical- Specific Risk	Total Pathway Risk
Arsenic, Dissolved	5.091E-08	1.438E-08	YES	YES	0.0003	NA	IRIS, 93	1	2E-04		5E-05	
Tetrachloroethylene	2.263E-07	6.478E-08	YES	YES	0.01	NA	IRIS, 93	1	2E-05		6E-06	
Total										2E-04		6E-05

Groundwater Solute Transport Model Data - Site 2

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemical's concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.
2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.
3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.
4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.
5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.

6. Vertical variations in head and concentrations are negligible.
7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft²/day at TF4-MW3 to 15,290 ft²/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and Cherry, 1982). A more complete description of the model is given in the report,

Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^n (h_m - h_s)^2]^{0.5}$$

n = number of wells
h_m = measured head
h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51
CG3MW3	9,23	676.50	675.98	0.52

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW4_5*	8,23	676.41	676.08	0.33
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76
S1MW3	13,27	677.15	676.98	0.17

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = $128.78/38 = 3.3891$

Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

- * The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).
- * The initial head data input to the transport model are results of measurements taken in September 1993.
- * Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.
- * Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.
- * The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.
- * The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 2

PCE was detected in two wells at Site 2. Wells MP2MW7 and MP2MW1 contained concentrations of PCE of 6.3 and 7.2 ug/l, respectively. These concentrations were input to the model at their respective nodes and the concentrations were monitored at Production Well #2 and at the sinkhole with respect to time.

Appendix R: Site 3 Risk Assessment

Table R-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Soils and Subsoils - Site 3
MIANG, Alpena CRTG, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE	RESULT
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(a)anthracene	0.0000	230.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(a)anthracene	0.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(a)anthracene	0.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Benzo(a)anthracene	4.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Benzo(a)anthracene	10.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Benzo(a)anthracene	4.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Benzo(a)anthracene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Benzo(a)anthracene	4.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Benzo(a)anthracene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Benzo(a)anthracene	8.0000	520.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(a)pyrene	0.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(a)pyrene	0.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(a)pyrene	0.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Benzo(a)pyrene	4.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Benzo(a)pyrene	10.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Benzo(a)pyrene	4.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Benzo(a)pyrene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Benzo(a)pyrene	4.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Benzo(a)pyrene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Benzo(a)pyrene	8.0000	350.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(b)fluoranthene	0.0000	300.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(b)fluoranthene	0.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(b)fluoranthene	0.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Benzo(b)fluoranthene	4.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Benzo(b)fluoranthene	10.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Benzo(b)fluoranthene	4.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Benzo(b)fluoranthene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Benzo(b)fluoranthene	4.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Benzo(b)fluoranthene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Benzo(b)fluoranthene	8.0000	770.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(k)fluoranthene	0.0000	300.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(k)fluoranthene	0.0000	170.0000

Table R-1A (continued)
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Soils and Subsoils - Site 3
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE	RESULT
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(k)fluoranthene	0.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Benzo(k)fluoranthene	4.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Benzo(k)fluoranthene	10.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Benzo(k)fluoranthene	4.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Benzo(k)fluoranthene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Benzo(k)fluoranthene	4.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Benzo(k)fluoranthene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Benzo(k)fluoranthene	8.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Chrysene	0.0000	770.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Chrysene	2.0000	210.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Chrysene	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB13-SS00-02	SUBSOIL	Chrysene	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Chrysene	4.0000	170.0000
PC-CG3	SB12	PC-CG3-SB11-SS10-12	SUBSOIL	Chrysene	10.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Chrysene	4.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Chrysene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Chrysene	4.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Chrysene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Chrysene	8.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Dibenzofuran	0.0000	530.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Dibenzofuran	2.0000	173.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Dibenzofuran	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Dibenzofuran	4.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Dibenzofuran	10.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Dibenzofuran	4.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Dibenzofuran	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Dibenzofuran	4.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Dibenzofuran	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Dibenzofuran	8.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Indeno(1,2,3-c,d)pyrene	0.0000	150.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Indeno(1,2,3-c,d)pyrene	2.0000	165.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Indeno(1,2,3-c,d)pyrene	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Indeno(1,2,3-c,d)pyrene	4.0000	170.0000

Table R-1A (continued)
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Soils and Subsoils - Site 3
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE	RESULT
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Indeno(1,2,3-c,d)pyrene	10.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Indeno(1,2,3-c,d)pyrene	4.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Indeno(1,2,3-c,d)pyrene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Indeno(1,2,3-c,d)pyrene	4.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Indeno(1,2,3-c,d)pyrene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Indeno(1,2,3-c,d)pyrene	8.0000	190.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Phenanthrene	0.0000	305.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Phenanthrene	0.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Phenanthrene	0.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Phenanthrene	4.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Phenanthrene	10.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Phenanthrene	4.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Phenanthrene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Phenanthrene	4.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Phenanthrene	10.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Phenanthrene	8.0000	1500.0000

Table R-2A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Surface Soils - Site 3
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE	RESULT
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(a)anthracene	0.0000	230.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(a)anthracene	0.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(a)anthracene	0.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(b)fluoranthene	0.0000	300.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(b)fluoranthene	0.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(b)fluoranthene	0.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(k)fluoranthene	0.0000	300.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(k)fluoranthene	0.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(k)fluoranthene	0.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Chrysene	0.0000	210.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Chrysene	0.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Chrysene	0.0000	170.0000

TABLE R-1 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH SOILS
Site 3, Former County Garage, Alpena CRTIC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Skin Surface Area Available for Contact (cm ² /day)	3120
Soil to Skin Adherence Factor (mg/cm ²)	2.77
Absorption Factor, Unitless	0.01
Organics	0.25
Exposure Factor (days/year)	250
Exposure Duration (year)	0.08
Body Weight (kilograms)	70
Conversion Factor	1E-06
Averaging Time, years	70
Carcinogens	0.08
Noncarcinogens	0.08

Recreational Adult Assumes that the adult works at the recreational facility 250 days /year and participates in recreational activities another 48 days per year

TABLE R-2 DAILY INTAKE - EXCAVATION WORKER
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 3, Former County Garage, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Benz(a)pyrene	2.210E-01	1.00E-06	3120	2.77	0.25	250	0.08	70	29.2	4.672E-06
Dibenzofuran	1.721E-01	1.00E-06	3120	2.77	0.25	250	0.08	70	29.2	3.638E-06
Phenanthrene	5.588E-01	1.00E-06	3120	2.77	0.25	250	0.08	70	29.2	1.181E-05

TABLE R-3 DAILY INTAKE - EXCAVATION WORKER
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 3, Former County Garage, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Benz(a)pyrene	2.210E-01	1.0E-06	3120	2.77	0.25	250	0.08	70	25550	5.339E-09
Dibenzofuran	1.730E-01	1.0E-06	3120	2.77	0.25	250	0.08	70	25550	4.180E-09
Phenanthrene	5.588E-01	1.0E-06	3120	2.77	0.25	250	0.08	70	25550	1.350E-08

TABLE R-4 EXPOSURE ASSESSMENT PARAMETERS - SOIL INGESTION
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Ingestion Rate (mg/day)	480
Fraction Ingested from Contaminated Sources (unitless)	1
Exposure Frequency (days/year)	250
Exposure Duration (years)	0.08
Body Weight (kilograms)	70
Conversion Factor	1E-06
Averaging Time, years	70
Carcinogens	0.08
Noncarcinogens	0.08

TABLE R-5 DAILY INTAKE
SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Benzo(a)pyrene	0.220994	1E-06	480	1	250	0.08	70	29.2	1.038E-06
Dibenzofuran	0.173	1E-06	480	1	250	0.08	70	29.2	8.125E-07
Phenanthrene	0.55879078	1E-06	480	1	250	0.08	70	29.2	2.624E-06

TABLE R-6 DAILY INTAKE
SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Benzo(a)pyrene	0.220994	1E-06	480	1	250	0.08	70	25550	1.186E-09
Dibenzofuran	0.173	1E-06	480	1	250	0.08	70	25550	9.286E-10
Phenanthrene	0.55879078	1E-06	480	1	250	0.08	70	25550	2.999E-09

TABLE R-7 EXPOSURE ASSESSMENT PARAMETERS - SOIL INHALATION
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Inhalation Rate, (mg/cu m)	20
Exposure Time (hours/day)	8
Exposure Frequency (days/year)	250
Exposure Duration (years)	0.08
Body Weight (kilograms)	70
Averaging Time (years)	70
Carcinogens	0.08
Noncarcinogens	

TABLE R-8 DAILY INTAKE
SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Concentration (mg/cu m)	Exposure Duration (years)	Inhalation Rate (cu m/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Weight (kg)	Time (days)	Intake Rate (mg/kg-day)
Benzo(a)pyrene	2.210E-06	0.08	20	8	250	70	29.2	3.480E-06
Dibenzofuran	1.721E-06	0.08	20	8	250	70	29.2	2.694E-06
Phenanthrene	5.588E-06	0.08	20	8	250	70	29.2	8.748E-06

TABLE R-9 DAILY INTAKE - ADULT
SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Concentration (mg/cu m)	Exposure Duration (years)	Inhalation Rate (cu m/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Weight (kg)	Time (days)	Intake Rate (mg/kg-day)
Benzo(a)pyrene	2.210E-06	0.08	20	8	250	70	25550	3.954E-09
Dibenzofuran	1.721E-06	0.08	20	8	250	70	25550	3.079E-09
Phenanthrene	5.588E-06	0.08	20	8	250	70	25550	9.998E-09

TABLE R-11 SOIL INHALATION MODEL CALCULATION
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Contribution from:		Dust Loading Factor (g/m ³)		Dust Loading Factor (g/m ³)		Dust Loading Factor (g/m ³)	
Compound	Concentration (mg/kg)	Conversion Factor	Concentration (mg/kg)	Conversion Factor	Concentration (mg/kg)	Conversion Factor	Concentration (mg/kg)
Benzo(a)pyrene	0.220994	0.001	0.220994	0.001	0.220994	0.001	0.220994
Benzo(a)anthracene	2.21E-06	0.001	2.21E-06	0.001	2.21E-06	0.001	2.21E-06
Chrysene	8.84E-07	0.001	8.84E-07	0.001	8.84E-07	0.001	8.84E-07
Dibenz(a,h)anthracene	1.720669E-06	0.001	1.720669E-06	0.001	1.720669E-06	0.001	1.720669E-06
Phenanthrene	0.559737E-05	0.001	0.559737E-05	0.001	0.559737E-05	0.001	0.559737E-05
Pyrene	5.49E-06	0.001	5.49E-06	0.001	5.49E-06	0.001	5.49E-06
Fluoranthene	2.23516312E-06	0.001	2.23516312E-06	0.001	2.23516312E-06	0.001	2.23516312E-06

TABLE R-14 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effects

Site 3, Former County Courthouse, Alpena, MI

Chemical	Excavation Worker CDI (mg/day)	CDI Adjusted for Absorption	Subchronic RfD (mg/kg-day)	Chemical Effect	RfD Source	Adjusting Factor	Excavation Chemical Specific Risk	Total Pathway Risk
Benzodibenzene	8.14E-06	0.3	0.3	HA	HEAST 93(1)	1	3E-06	
Phenanthrene	2.62E-06	0.3	0.3	HA	HEAST 93(1)	1	9E-06	
Total								1E-05

1) Subchronic RfD for pyrene was used (HEAST 93)

TABLE R-15 CANCER ESTIMATE - SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effects

Site 3, Former County Courthouse, Alpena, MI

Chemical	Excavation Worker CDI (mg/day)	CDI Adjusted for Absorption	SF	Weight of Evidence	Type of Cancer	SF Source	Excavation Chemical Specific Risk
Benzodibenzene	8.14E-06	NO	7.1	NA	Fore Stomach	HEAST 93	9E-09
Phenanthrene	2.62E-06	NO	NO EVIDENCE	NA	Lung, Throat, Lower Sin	HEAST 93	9E-09
Total							9E-09

1) Oral Slope factor for Benzodibenzene was used

TABLE R-12 CANCER ESTIMATE - DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Carcinogenic Effects									
Site 3, Former County Garage, Alpena CRTC, Alpena, MI									
Chemical	Excavation Worker CDI (mg/kg-day)	Adjusted for Absorption	Subchronic RD* (mg/kg-day)	Critical Effect	RD Source	Modifying Factor	Excavation Chemical-Specific Risk	Total Pathway Risk	
Benz(a)pyrene	5.33E-09	YES	NO EVIDENCE	NA	(a)	1	2E-07	2E-07	
Dibenz(a,h)anthracene	4.18E-09	YES	NO EVIDENCE	NA	(a)	1	0E+00	0E+00	
Phenanthrene	1.35E-08	YES	NO EVIDENCE	NA	(a)	1	0E+00	0E+00	
Total									2E-07

(a) SF for benzo(a) pyrene used (RIS, 93).
* Adjusted from administered and absorbed dose by assuming an efficiency of 0.17 (ASTDR 1990 for benzo(a)pyrene) and 0.67 for Chrysene (ASTDR, 1990)

TABLE R-13 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Noncarcinogenic Effects									
Site 3, Former County Garage, Alpena CRTC, Alpena, MI									
Chemical	Excavation Worker CDI (mg/kg-day)	Adjusted for Absorption	Subchronic RD* (mg/kg-day)	Critical Effect	RD Source	Modifying Factor	Excavation Chemical-Specific Risk	Total Pathway Risk	
Benz(a)pyrene	4.67E-08	YES	NO DATA	NA	(a)	1	9E-05	9E-05	
Dibenz(a,h)anthracene	3.63E-08	YES	NO DATA	NA	(a)	1	2E-04	2E-04	
Phenanthrene	1.18E-05	YES	NO DATA	NA	(a)	1	2E-04	2E-04	
Total									3E-04

(a) RD for benzo(a) pyrene used (HEAST, 93).

TABLE R-16 CANCER RISK ESTIMATE - SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Chemical Specific

Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Excavation CDI (mg/kg-day)	Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	Source SF	Excavation Chemical- Specific Risk	Total Pathway Risk
Benzo(a)pyrene	3.07E-09	NO	NO EVIDENCE	NA	Respiratory Tract	RIS-93	3E-08	
Dibenz(a,h)anthracene	9.59E-09	NO	NO EVIDENCE	NA	NA	NA	0E+00	
Phenanthrene								
Total								3E-08

1) Oral slope factor for benzo(a)pyrene was used, RIS.

TABLE R-17 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Chemical Specific

Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Excavation CDI (mg/kg-day)	Adjusted for Absorption	Subchronic RDI (mg/kg-day)	Critical Effect	RDI Source	Modifying Factor	Excavation Chemical- Specific Risk	Total Pathway Risk
Benzo(a)pyrene	3.40E-06	NO	0.3	NA	HEAST 93	1	1E-05	
Dibenz(a,h)anthracene	8.74E-06	NO	0.0057	NA	HEAST 93	1	2E-03	
Phenanthrene				Liver	CAEPA 92	1		
Total								2E-03

* RDI for corresponding subchronic oral RDI was used.

Groundwater Solute Transport Model Data - Site 3

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTS. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemical's concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.
2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.
3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.
4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.
5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.

6. Vertical variations in head and concentrations are negligible.
7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft²/day at TF4-MW3 to 15,290 ft²/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3-dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and

Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^n (h_m - h_s)^2]^{0.5}$$

n = number of wells
 h_m = measured head
 h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = $128.78/38 = 3.3891$
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

- * The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).
- * The initial head data input to the transport model are results of measurements taken in September 1993.
- * Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.
- * Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.
- * The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.
- * The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 3

No organic compounds or inorganics exceeding the Act 307 Type A or B cleanup criteria were present in the shallow aquifer at this site.

Appendix S: Site 4 Risk Assessment

Table S-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 4
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-TF4	MW1	PC-TF4-MW1-GW4	GROUNDWATER	bis(2-Ethylhexyl)phthalate	3.2000

Table S-2A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Sediment - Site 4
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE	RESULT
PC-TF4	SD001	PC-TF4-SD001	SEDIMENT	4-Methylphenol	0.0000	365.0000
PC-TF4	SD001	PC-TF4-SD001	SEDIMENT	Selenium	0.0000	1.1000
PC-TF4	SD001A	PC-TF4-SD001A	SEDIMENT	Methylene chloride	0.0000	4.2000
PC-TF4	SD001A	PC-TF4-SD001A	SEDIMENT	Selenium	0.0000	0.2150
PC-TF4	SD002B	PC-TF4-SD002B	SEDIMENT	4-Methylphenol	0.0000	235.0000
PC-TF4	SD002B	PC-TF4-SD002B	SEDIMENT	Selenium	0.0000	0.2150
PC-TF4	SD002B	PC-TF4-SD002B	SEDIMENT	Methylene chloride	0.0000	5.6000
PC-TF4	SD002B	PC-TF4-SD002B	SEDIMENT	4-Methylphenol	0.0000	235.0000
PC-TF4	SD003	PC-TF4-SD003	SEDIMENT	4-Methylphenol	0.0000	220.0000
PC-TF4	SD003	PC-TF4-SD003	SEDIMENT	Selenium	0.0000	0.4200
PC-TF4	SD004A	PC-TF4-SD004A	SEDIMENT	Methylene chloride	0.0000	12.0000
PC-TF4	SD004A	PC-TF4-SD004A	SEDIMENT	Methylene chloride	0.0000	4.9000
PC-TF4	SD004A	PC-TF4-SD004A	SEDIMENT	4-Methylphenol	0.0000	215.0000
PC-TF4	SD004B	PC-TF4-SD004B	SEDIMENT	Selenium	0.0000	0.1950
PC-TF4	SD004B	PC-TF4-SD004B	SEDIMENT	Methylene chloride	0.0000	2.8000
PC-TF4	SD005A	PC-TF4-SD005A	SEDIMENT	Selenium	0.0000	0.2000
PC-TF4	SD005A	PC-TF4-SD005A	SEDIMENT	4-Methylphenol	0.0000	217.0000
PC-TF4	SD005B	PC-TF4-SD005B	SEDIMENT	4-Methylphenol	0.0000	315.0000
PC-TF4	SD005B	PC-TF4-SD005B	SEDIMENT	Selenium	0.0000	0.7200
PC-TF4	SD005B	PC-TF4-SD005B	SEDIMENT	Selenium	0.0000	215.0000
PC-TF4	SD006A	PC-TF4-SD006A	SEDIMENT	Methylene chloride	0.0000	0.2000
PC-TF4	SD006A	PC-TF4-SD006A	SEDIMENT	Selenium	0.0000	16.0000
PC-TF4	SD006A	PC-TF4-SD006A	SEDIMENT	Methylene chloride	0.0000	0.2000
PC-TF4	SD006B	PC-TF4-SD006B	SEDIMENT	4-Methylphenol	0.0000	215.0000
PC-TF4	SD006B	PC-TF4-SD006B	SEDIMENT	Selenium	0.0000	2.9000
PC-TF4	SD009A	PC-TF4-SD009A	SEDIMENT	Methylene chloride	0.0000	0.2200
PC-TF4	SD009A	PC-TF4-SD009A	SEDIMENT	4-Methylphenol	0.0000	144.0000
PC-TF4	SD009A	PC-TF4-SD009A	SEDIMENT	Methylene chloride	0.0000	1.9000
PC-TF4	SD009A	PC-TF4-SD009A	SEDIMENT	4-Methylphenol	0.0000	170.0000
PC-TF4	SD010A	PC-TF4-SD010A	SEDIMENT	Selenium	0.0000	0.1550
PC-TF4	SD010A	PC-TF4-SD010A	SEDIMENT	4-Methylphenol	0.0000	250.0000
PC-TF4	SD010A	PC-TF4-SD010A	SEDIMENT	Selenium	0.0000	0.2300
PC-TF4	SD010A	PC-TF4-SD010A	SEDIMENT	Methylene chloride	0.0000	0.7500

Table S-3A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Surface Water - Site 4
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-TF4	SW006	PC-TF4-SW006	SURFACE WATER	Selenium, Dissolved	3.5000
PC-TF4	SW007	PC-TF4-SW007	SURFACE WATER	Selenium, Dissolved	1.5000
PC-TF4	SW008	PC-TF4-SW008	SURFACE WATER	Selenium, Dissolved	1.5000
PC-TF4	SW006	PC-TF4-SW006	SURFACE WATER	Trichloroethylene	1.2000
PC-TF4	SW007	PC-TF4-SW007	SURFACE WATER	Trichloroethylene	0.1500
PC-TF4	SW008	PC-TF4-SW008	SURFACE WATER	Trichloroethylene	0.0950

TABLE S-1 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH SEDIMENTS
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (cm ² /day)	3120	1490
Soil to Skin Adherence Factor (mg/cm ²)	2.77	2.77
Absorption Factor, Unitless		
Metals	0.01	0.01
Organics	0.25	0.25
Exposure Factor (days/year)	48	48
Exposure Duration (year)	25	15
Body Weight (kilograms)	70	27
Conversion Factor	1E-06	1E-06
Averaging Time, years		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE S-2 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Soil to Skin Adherence (mg/cm ²)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Selenium	4.875E-01	1.00E-06	3120	2.77	0.01	48	25	70	9125	7.915E-08
Methylene chloride	8.802E-03	1.00E-06	3120	2.77	0.25	48	25	70	9125	3.573E-08
4-Methylphenol	2.634E-01	1.00E-06	3120	2.77	0.25	48	25	70	9125	1.069E-06

TABLE S-3 DAILY INTAKE - CHILD
DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Soil to Skin Adherence (mg/cm ²)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Selenium	4.875E-01	1.00E-06	1490	2.77	0.01	48	15	27	5475	9.800E-08
Methylene chloride	8.802E-03	1.00E-06	1490	2.77	0.25	48	15	27	5475	4.424E-08
4-Methylphenol	2.634E-01	1.00E-06	1490	2.77	0.25	48	15	27	5475	1.324E-06

TABLE S-4 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTG, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Soil to Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Selenium	4.875E-01	1.0E-06	3120	2.77	0.01	48	25	70	25550	2.827E-08
Methylene chloride	8.802E-03	1.0E-06	3120	2.77	0.25	48	25	70	25550	1.276E-08
4-Methylphenol	2.634E-01	1.0E-06	3120	2.77	0.25	48	25	70	25550	3.818E-07

TABLE S-5 DAILY INTAKE - CHILD
DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTG, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Soil to Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Selenium	4.875E-01	1.0E-06	1490	2.77	0.01	48	15	27	25550	2.100E-08
Methylene chloride	8.802E-03	1.0E-06	1490	2.77	0.25	48	15	27	25550	9.479E-09
4-Methylphenol	2.634E-01	1.0E-06	1490	2.77	0.25	48	15	27	25550	2.898E-07

TABLE S-6 EXPOSURE ASSESSMENT PARAMETERS - SEDIMENT INGESTION
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	CHILD	ADULT
Ingestion Rate (mg/day)	200	100
Fraction Ingested from Contaminated Sources (unitless)	1	1
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	6	25
Body Weight (kilograms)	15	70
Conversion Factor	1E-06	1E-06
Averaging Time	70	70
Carcinogens	6	25
Noncarcinogens		

TABLE S-7 DAILY INTAKE - ADULT
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Selenium	4.875E-01	1E-06	100	1	48	25	70	9125	9.158E-08
Methylene chloride	8.802E-03	1E-06	100	1	48	25	70	9125	1.654E-09
4-Methylphenol	2.634E-01	1E-06	100	1	48	25	70	9125	4.948E-08

TABLE S-8 DAILY INTAKE CHILD
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Selenium	4.875E-01	1E-06	200	1	48	6	15	2190	8.548E-07
Methylene chloride	8.802E-03	1E-06	200	1	48	6	15	2190	1.543E-08
4-Methylphenol	2.634E-01	1E-06	200	1	48	6	15	2190	4.618E-07

TABLE S-9 DAILY INTAKE - ADULT
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Selenium	4.875E-01	1E-06	100	1	48	25	70	25550	3.271E-08
Methylene chloride	8.802E-03	1E-06	100	1	48	25	70	25550	5.906E-10
4-Methylphenol	2.634E-01	1E-06	100	1	48	25	70	25550	1.767E-08

TABLE S-10 DAILY INTAKE - CHILD
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Selenium	4.875E-01	1E-06	200	1	48	6	15	25550	7.327E-08
Methylene chloride	8.802E-03	1E-06	200	1	48	6	15	25550	1.323E-09
4-Methylphenol	2.634E-01	1E-06	200	1	48	6	15	25550	3.958E-08

TABLE S-11 EXPOSURE ASSESSMENT PARAMETERS - FISH INGESTION
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Fraction of Fish Ingested, unitless	0.5	0.5
Ingestion rate kg/day	0.054	0.043
Exposure Frequency days/yr	26	26
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE S-12 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical * Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.680E-02	0.054	26	0.5	25	70	9125	1.286E-06
Selenium, dissolved	3.500E-03	0.054	26	0.5	25	70	9125	9.616E-08
Carbon Tetrachloride	1.377E-03	0.054	26	0.5	25	70	9125	3.783E-08
Tetrachloroethylene	1.624E-03	0.054	26	0.5	25	70	9125	4.462E-08
Arsenic	2.000E-06	0.054	26	0.5	25	70	9125	5.495E-11
Benzene	3.722E-02	0.054	26	0.5	25	70	9125	1.023E-06
Styrene	1.000E-03	0.054	26	0.5	25	70	9125	2.748E-08
1,2 Dichloroethane	2.000E-05	0.054	26	0.5	25	70	9125	5.495E-10
1,4 Dichlorobenzene	6.300E-03	0.054	26	0.5	25	70	9125	1.731E-07
2 Methylanththalene	5.100E-03	0.054	26	0.5	25	70	9125	1.401E-07
Lead	4.000E-04	0.054	26	0.5	25	70	9125	1.099E-08

* Adjusted from surface water to fish concentrations by use of bioconcentration factors, Cr=20, Cu=50.

TABLE S-13 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical * Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.680E-02	0.043	26	0.5	15	27	5475	2.655E-06
Selenium, dissolved	3.500E-03	0.043	26	0.5	15	27	5475	1.985E-07
Carbon Tetrachloride	1.377E-03	0.043	26	0.5	15	27	5475	7.811E-08
Tetrachloroethylene	1.624E-03	0.043	26	0.5	15	27	5475	9.212E-08
Arsenic	2.000E-06	0.043	26	0.5	15	27	5475	1.134E-10
Benzene	3.722E-02	0.043	26	0.5	15	27	5475	2.111E-06
Styrene	1.000E-03	0.043	26	0.5	15	27	5475	5.672E-08
1,2 Dichloroethane	2.000E-05	0.043	26	0.5	15	27	5475	1.134E-09
1,4 Dichlorobenzene	6.300E-03	0.043	26	0.5	15	27	5475	3.574E-07
2 Methylanththalene	5.100E-03	0.043	26	0.5	15	27	5475	2.893E-07
Lead	4.000E-04	0.043	26	0.5	15	27	5475	2.269E-08

* Adjusted from surface water to fish concentrations by use of bioconcentration factors, Cr=20, Cu=50.

TABLE S-14 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.680E-02	0.054	26	0.5	25	70	25550	4.592E-07
Selenium, dissolved	3.500E-03	0.054	26	0.5	25	70	25550	3.434E-08
Carbon Tetrachloride	1.377E-03	0.054	26	0.5	25	70	25550	1.351E-08
Tetrachloroethylene	1.624E-03	0.054	26	0.5	25	70	25550	1.594E-08
Arsenic	2.000E-06	0.054	26	0.5	25	70	25550	1.963E-11
Benzene	3.722E-02	0.054	26	0.5	25	70	25550	3.653E-07
Styrene	1.000E-03	0.054	26	0.5	25	70	25550	9.813E-09
1,2 Dichloroethane	2.000E-05	0.054	26	0.5	25	70	25550	1.963E-10
1,4 Dichlorobenzene	6.300E-03	0.054	26	0.5	25	70	25550	6.182E-08
2 Methyl naphthalene	5.100E-03	0.054	26	0.5	25	70	25550	5.004E-08
Lead	4.000E-04	0.054	26	0.5	25	70	25550	3.925E-09

TABLE S-15 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.680E-02	0.043	26	0.5	15	27	25550	5.686E-07
Selenium, dissolved	3.500E-03	0.043	26	0.5	15	27	25550	4.254E-08
Carbon Tetrachloride	1.377E-03	0.043	26	0.5	15	27	25550	1.674E-08
Tetrachloroethylene	1.624E-03	0.043	26	0.5	15	27	25550	1.974E-08
Arsenic	2.000E-06	0.043	26	0.5	15	27	25550	2.431E-11
Benzene	3.722E-02	0.043	26	0.5	15	27	25550	4.525E-07
Styrene	1.000E-03	0.043	26	0.5	15	27	25550	1.215E-08
1,2 Dichloroethane	2.000E-05	0.043	26	0.5	15	27	25550	2.431E-10
1,4 Dichlorobenzene	6.300E-03	0.043	26	0.5	15	27	25550	7.668E-08
2 Methyl naphthalene	5.100E-03	0.043	26	0.5	15	27	25550	6.199E-08
Lead	4.000E-04	0.043	26	0.5	15	27	25550	4.862E-09

TABLE S-16 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF SURFACE WATER
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Exposure Time (hrs/day)	2.6	2.6
Surface Water Contact Rate (ml/hr)	50	50
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time	70	70
Carcinogens	25	15
Noncarcinogens		

TABLE S-17 DAILY INTAKE - ADULT
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/hr)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/kg-day)
Trichloroethylene	4.816E-04	0.050	48	2.6	25	70	9125	1.176E-07
Selenium, dissolved	2.100E-03	0.050	48	2.6	25	70	9125	5.129E-07
Carbon Tetrachloride	8.100E-05	0.050	48	2.6	25	70	9125	1.978E-08
Tetrachloroethylene	2.900E-05	0.050	48	2.6	25	70	9125	7.083E-09
Arsenic	2.000E-06	0.050	48	2.6	25	70	9125	4.885E-10
Benzene	1.551E-03	0.050	48	2.6	25	70	9125	3.788E-07
Styrene	1.000E-05	0.050	48	2.6	25	70	9125	2.442E-09
1,2 Dichloroethane	1.000E-05	0.050	48	2.6	25	70	9125	2.442E-09
1,4 Dichlorobenzene	1.050E-04	0.050	48	2.6	25	70	9125	2.564E-08
2 Methylanthralene	1.000E-05	0.050	48	2.6	25	70	9125	2.442E-09
Lead	4.000E-06	0.050	48	2.6	25	70	9125	9.769E-10

TABLE S-18 DAILY INTAKE - CHILD
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/hr)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.816E-04	0.050	48	2.6	15	27	5475	3.049E-07
Selenium, dissolved	2.100E-03	0.050	48	2.6	15	27	5475	1.330E-06
Carbon Tetrachloride	8.100E-05	0.050	48	2.6	15	27	5475	5.129E-08
Tetrachloroethylene	2.900E-05	0.050	48	2.6	15	27	5475	1.836E-08
Arsenic	2.000E-06	0.050	48	2.6	15	27	5475	1.266E-09
Benzene	1.551E-03	0.050	48	2.6	15	27	5475	9.821E-07
Styrene	1.000E-05	0.050	48	2.6	15	27	5475	6.332E-09
1,2 Dichloroethane	1.000E-05	0.050	48	2.6	15	27	5475	6.332E-09
1,4 Dichlorobenzene	1.050E-04	0.050	48	2.6	15	27	5475	6.648E-08
2 Methylanthralene	1.000E-05	0.050	48	2.6	15	27	5475	6.332E-09
Lead	4.000E-06	0.050	48	2.6	15	27	5475	2.533E-09

TABLE S-19 DAILY INTAKE - ADULT
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/hr)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.816E-04	0.050	48	2.6	25	70	25550	4.201E-08
Selenium, dissolved	2.100E-03	0.050	48	2.6	25	70	25550	1.832E-07
Carbon Tetrachloride	8.100E-05	0.050	48	2.6	25	70	25550	7.065E-09
Tetrachloroethylene	2.900E-05	0.050	48	2.6	25	70	25550	2.529E-09
Arsenic	2.000E-06	0.050	48	2.6	25	70	25550	1.744E-10
Benzene	1.551E-03	0.050	48	2.6	25	70	25550	1.353E-07
Styrene	1.000E-05	0.050	48	2.6	25	70	25550	8.722E-10
1,2 Dichloroethane	1.000E-05	0.050	48	2.6	25	70	25550	8.722E-10
1,4 Dichlorobenzene	1.050E-04	0.050	48	2.6	25	70	25550	9.159E-09
2 Methylthiophene	1.000E-05	0.050	48	2.6	25	70	25550	8.722E-10
Lead	4.000E-06	0.050	48	2.6	25	70	25550	3.489E-10

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TABLE S-20 DAILY INTAKE - CHILD
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/hr)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	1.200E-03	0.050	48	2.6	15	27	25550	1.628E-07
Selenium, dissolved	3.500E-03	0.050	48	2.6	15	27	25550	4.749E-07
Carbon Tetrachloride	8.100E-05	0.050	48	2.6	15	27	25550	1.099E-08
Tetrachloroethylene	2.900E-05	0.050	48	2.6	15	27	25550	3.935E-09
Arsenic	2.000E-06	0.050	48	2.6	15	27	25550	2.714E-10
Benzene	1.551E-03	0.050	48	2.6	15	27	25550	2.104E-07
Styrene	1.000E-05	0.050	48	2.6	15	27	25550	1.357E-09
1,2 Dichloroethane	1.000E-05	0.050	48	2.6	15	27	25550	1.357E-09
1,4 Dichlorobenzene	1.050E-04	0.050	48	2.6	15	27	25550	1.425E-08
2 Methylthiophene	1.000E-05	0.050	48	2.6	15	27	25550	1.357E-09
Lead	4.000E-06	0.050	48	2.6	15	27	25550	5.427E-10

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TABLE S-21 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH THUNDERBAY RIVER SURFACE WATER
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	2.6	2.6
Dermal Permeability Constant	0.00084	0.00084
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	

TABLE S-22 DAILY INTAKE - ADULT
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/kg-day)
Trichloroethylene	(a) 1.200E-03	0.2	19400	48	2.6	25	70	9125	0.001	2.274E-05
Selenium, dissolved	(c) 3.500E-03	0.001	19400	48	2.6	25	70	9125	0.001	3.317E-07
Carbon Tetrachloride	(b) 8.100E-05	0.022	19400	48	2.6	25	70	9125	0.001	1.689E-07
Tetrachloroethylene	(a) 2.900E-05	0.4	19400	48	2.6	25	70	9125	0.001	1.099E-06
Arsenic	(c) 2.000E-06	0.001	19400	48	2.6	25	70	9125	0.001	1.895E-10
Benzene	(a) 1.551E-03	0.1	19400	48	2.6	25	70	9125	0.001	1.470E-05
Styrene	(b) 1.000E-05	0.0084	19400	48	2.6	25	70	9125	0.001	7.960E-10
1,2 Dichloroethane	(b) 1.000E-05	0.0053	19400	48	2.6	25	70	9125	0.001	5.022E-09
1,4 Dichlorobenzene	(b) 1.050E-04	0.062	19400	48	2.6	25	70	9125	0.001	6.169E-07
2 Methylanthralene	(c) 1.000E-05	0.001	19400	48	2.6	25	70	9125	0.001	9.476E-10
Lead	(a) 4.000E-06	4E-06	19400	48	2.6	25	70	9125	0.001	1.516E-12

- (a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a)
(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a)
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a)

TABLE S-23 DAILY INTAKE - CHILD
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/kg-day)
Trichloroethylene	(a) 1.200E-03	0.2	13300	48	2.6	15	27	5475	0.001	4.042E-05
Selenium, dissolved	(b) 3.500E-03	0.001	13300	48	2.6	15	27	5475	0.001	5.895E-07
Carbon Tetrachloride	(b) 8.100E-05	0.022	13300	48	2.6	15	27	5475	0.001	3.001E-07
Tetrachloroethylene	(a) 2.900E-05	0.4	13300	48	2.6	15	27	5475	0.001	1.954E-06
Arsenic	(c) 2.000E-06	0.001	13300	48	2.6	15	27	5475	0.001	3.369E-10
Benzene	(a) 1.551E-03	0.1	13300	48	2.6	15	27	5475	0.001	2.612E-05
Styrene	(b) 1.000E-05	0.0084	13300	48	2.6	15	27	5475	0.001	1.415E-09
1,2 Dichloroethane	(b) 1.000E-05	0.0053	13300	48	2.6	15	27	5475	0.001	8.927E-09
1,4 Dichlorobenzene	(b) 1.050E-04	0.062	13300	48	2.6	15	27	5475	0.001	1.096E-06
2 Methylanthralene	(c) 1.000E-05	0.001	13300	48	2.6	15	27	5475	0.001	1.684E-09
Lead	(a) 4.000E-06	4E-06	13300	48	2.6	15	27	5475	0.001	2.695E-12

- (a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a)
(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a)
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a)

TABLE S-24 DAILY INTAKE - ADULT
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
 Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/kg-day)
Trichloroethylene	(a) 1.200E-03	0.2	19400	48	2.6	25	70	25550	0.001	8.122E-06
Selenium, dissolved	(b) 3.500E-03	0.001	19400	48	2.6	25	70	25550	0.001	1.185E-07
Carbon Tetrachloride	(b) 8.100E-05	0.022	19400	48	2.6	25	70	25550	0.001	6.031E-08
Tetrachloroethylene	(a) 2.900E-05	0.4	19400	48	2.6	25	70	25550	0.001	3.926E-07
Arsenic	(c) 2.000E-06	0.001	19400	48	2.6	25	70	25550	0.001	6.769E-11
Benzene	(a) 1.551E-03	0.1	19400	48	2.6	25	70	25550	0.001	5.249E-06
Styrene	1.000E-05	0.0084	19400	48	2.6	25	70	25550	0.001	2.843E-10
1,2 Dichloroethane	(b) 1.000E-05	0.0053	19400	48	2.6	25	70	25550	0.001	1.794E-09
1,4 Dichlorobenzene	(b) 1.050E-04	0.062	19400	48	2.6	25	70	25550	0.001	2.203E-07
2 Methylnaphthalene	(c) 1.000E-05	0.001	19400	48	2.6	25	70	25550	0.001	3.384E-10
Lead	(a) 4.000E-06	4E-06	19400	48	2.6	25	70	25550	0.001	5.415E-13

(a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).

TABLE S-25 DAILY INTAKE - CHILD
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
 Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/kg-day)
Trichloroethylene	(a) 1.200E-03	0.2	13300	48	2.6	15	27	25550	0.001	8.662E-06
Selenium, dissolved	(b) 3.500E-03	0.001	13300	48	2.6	15	27	25550	0.001	1.263E-07
Carbon Tetrachloride	(b) 8.100E-05	0.022	13300	48	2.6	15	27	25550	0.001	6.431E-08
Tetrachloroethylene	(a) 2.900E-05	0.4	13300	48	2.6	15	27	25550	0.001	4.187E-07
Arsenic	(c) 2.000E-06	0.001	13300	48	2.6	15	27	25550	0.001	7.218E-11
Benzene	(a) 1.551E-03	0.1	13300	48	2.6	15	27	25550	0.001	5.598E-06
Styrene	1.000E-05	0.0084	13300	48	2.6	15	27	25550	0.001	3.032E-10
1,2 Dichloroethane	(b) 1.000E-05	0.0053	13300	48	2.6	15	27	25550	0.001	1.913E-09
1,4 Dichlorobenzene	(b) 1.050E-04	0.062	13300	48	2.6	15	27	25550	0.001	2.350E-07
2 Methylnaphthalene	(c) 1.000E-05	0.001	13300	48	2.6	15	27	25550	0.001	3.609E-10
Lead	(a) 4.000E-06	4E-06	13300	48	2.6	15	27	25550	0.001	5.775E-13

TABLE 8-28 CANCER ESTIMATE - DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO - ADULTS/CHILDREN

Carcinogenic Effects Site 4, Third Fire Training Area, Alpena CRTG, Alpena, MI											
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	SF *	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Total Pathway Risk	Child Chemical- Specific Risk	Total Pathway Risk
Selenium	2.827E-08	2.100E-08	YES	NO EVIDENCE	B2	Liver	IRIS 93	0E+00		0E+00	
Methylene chloride	1.276E-08	9.479E-09	YES	7.65E-03	C	NA	NA	1E-10		7E-11	
4-Methylphenol	3.818E-07	2.836E-07	YES	NO DATA				0E+00		0E+00	
Total									1E-10		7E-11

* Adjusted for administered to absorbed using oral absorption efficiency factors, As=0.95 (ASTDR 1991), Cr=0.11 (ASTDR 1989), MeCl 0.98 (ASTDR 1991)

TABLE 3-27 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO - ADULTS/CHILDREN

Noncarcinogenic Effects

Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Child Chemical- Specific Risk	Total Pathway Risk
Selenium	7.915E-08	9.800E-08	YES	0.003	Critical Selenosis	IRIS 93	1	2E-05		2E-05	
Methylene chloride	3.573E-08	4.424E-08	YES	0.0588	Liver	IRIS 93	1	6E-07		8E-07	
4-Methylphenol	1.069E-06	1.324E-06	YES	0.003725	Decreased body weight	HEAST 83	1	3E-04		4E-04	
Total									3E-04		4E-04

* Adjusted for administered to absorbed using oral absorption efficiency factors. As=0.95 (ASTDR 1991), Cr=0.11 (ASTDR 1989), MeCl 0.98 (ASTDR 1989), 4-Methylphenol 0.745 (ASTDR 1992)

TABLE 9-28 CANCER ESTIMATE - SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - ADULTS/CHILDREN

Carcinogenic Effects Site 4, Third Fire Training Area, Alpena CRTIC, Alpena, MI									
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Child Chemical- Specific Risk
Selenium	3.27E-08	7.32E-08	NO	NO EVIDENCE	B2	Liver	IRIS 93	0E+00	0E+00
Methylene chloride	5.90E-10	1.32E-09	NO	0.0075	C	Skin	NA	4E-12	1E-11
4-Methylphenol	1.76E-06	3.95E-06	NO	NO DATA					
Total									

1) Converted from a unit risk of 5 X 10E-05 ug/L given in IRIS.

TABLE S-29 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - ADULTS/CHILDREN

Noncarcinogenic Effects

Site 4, Third Fire Training Area, Alpena CRT, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Child Chemical- Specific Risk	Total Pathway Risk
Selenium	9.15E-08	8.53E-07	NO	0.005	Critical sclerosis	IRIS 93	1	2E-05	2E-04	
Methylene chloride	1.654E-08	1.543E-08	NO	0.06	Liver	IRIS 93	1	3E-08	3E-07	
4-Methylpyrid	4.948E-08	4.618E-07	NO	0.005	Decreased body weight	HEAST 83		1E-05	9E-05	
Total								3E-05		3E-04

TABLE S-30 CANCER ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects Site 4, Third Fire Training Area, Alpena, MI									
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Children Chemical- Specific Risk
Trichloroethylene	4.592E-07	5.688E-07	NO	0.01	B2	Lung	CA EPA 92 (1)	5E-09	6E-09
Selenium, dissolved	3.434E-08	4.254E-08	NO	NO EVIDENCE		NA		0E+00	0E+00
Carbon Tetrachloride	1.351E-08	1.674E-08	NO	0.13	B2	Heptocellular carcinomas	IRIS 93	2E-09	2E-09
Tetrachloroethylene	1.594E-08	1.974E-08	NO	0.051	B2	Liver	CA EPA 92	8E-10	1E-09
Arsenic	1.963E-11	2.431E-11	NO	1.8	A	Skin, Lung	IRIS 93	4E-11	4E-11
Benzene	3.653E-07	4.525E-07	NO	0.029	A	Leukemia	IRIS 93	1E-08	1E-08
Styrene	9.813E-09	1.215E-08	NO	NO DATA	NA	NA	NA	0E+00	0E+00
1,2 Dichloroethane	1.963E-10	2.431E-10	NO	0.091	B2	Hemangiosarcomas	IRIS 93	2E-11	2E-11
1,4 Dichlorobenzene	6.182E-08	7.658E-08	NO	0.024	C	Liver tumors	HEAST 93	1E-09	2E-09
2-Methylnaphthalene	5.004E-08	6.199E-08	NO	NO EVIDENCE	NA	NA	NA	0E+00	0E+00
Lead	3.975E-09	4.862E-09	NO	NO DATA	B2	Kidney	NA	0E+00	0E+00
Total								2E-08	2E-08

TABLE S-31 CHRONIC HAZARDOUS INDEX ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects

Site 4, Third Fire Training Area, Alpena CRT, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Trichloroethylene	1.26E-06	2.65E-06	NO	0.00735	Red blood cells	CA EPA 92	1	2E-04		4E-04	
Selenium, dissolved	9.61E-08	1.98E-07	NO	0.005	Clinical Selenosis	IRIS, 1993	1	2E-05		4E-05	
Carbon Tetrachloride	3.78E-08	7.81E-08	NO	0.0007	Liver Lesions	IRIS, 1993	1	5E-05		1E-04	
Tetrachloroethylene	4.46E-08	9.21E-08	NO	0.01	Hepatotoxicity	IRIS, 1993	1	4E-06		9E-06	
Arsenic	5.49E-11	1.13E-10	NO	0.0003	Keratinosis	IRIS, 1993	1	2E-07		4E-07	
Benzene	1.02E-06	2.11E-06	NO	No Data	NA	NA	NA				
Styrene	2.74E-08	5.67E-08	NO	0.2	Red blood cell and liver	IRIS, 1993	1	1E-07		3E-07	
1,2 Dichloroethane	5.49E-10	1.13E-09	NO	No Data	NA	NA	NA				
1,4 Dichlorobenzene	1.73E-07	3.57E-07	NO	No Data	NA	NA	NA				
2 Methylphenanthrene	1.40E-07	2.89E-07	NO	0.03	NA	NA	NA	5E-06		1E-05	
Lead	1.09E-08	2.26E-08	NO	No Data	NA	NA	NA				
Total									3E-04		5E-04

1) RfD calculated from conversion of 1.3 mg/L drinking water standard.

TABLE S-37. CANCER ESTIMATE - SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects Site 4, Third Fire Training Area, Alpena CRT, Alpena, MI									
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Children Chemical- Specific Risk
Trichloroethylene	4.201E-08	4.392E-07	NO	0.01	B2	Lung	CA EPA 92 (1)	4E-10	5E-09
Selenium, dissolved	1.832E-07	3.434E-08	NO	NO EVIDENCE		NA		0E+00	0E+00
Carbon Tetrachloride	7.065E-09	1.099E-08	NO	0.13	B2	Hepatocellular carcinomas	IRIS 93	9E-10	1E-09
Tetrachloroethylene	2.529E-09	3.935E-09	NO	0.051	B2	Liver	CA EPA 92	1E-10	2E-10
Arsenic	1.744E-10	2.714E-10	NO	1.8	A	Skin, Lung	IRIS 93	3E-10	5E-10
Benzene	1.353E-07	2.104E-07	NO	0.029	A	Leukemia	IRIS 93	4E-09	6E-09
Styrene	8.722E-10	1.357E-09	NO	NO DATA	NA	NA	NA	0E+00	0E+00
1,2 Dichloroethane	8.722E-10	1.357E-09	NO	0.091	B2	Hemangiosarcomas	IRIS 93	8E-11	1E-10
1,4 Dichlorobenzene	9.159E-09	1.425E-08	NO	0.024	C	Liver tumors	Heast 93	2E-10	3E-10
2 Methylanthralene	8.722E-10	1.357E-09	NO	NO EVIDENCE	NA	NA	NA	0E+00	0E+00
Lead	3.489E-10	5.427E-10	NO	NO DATA	B2	Kidney	NA	0E+00	0E+00
Total								6E-09	1E-08

(a) Converted from a unit risk of 5e-5 ugi given in IRIS
(b) no SF exists for styrene as of 1/5/94. Classified as probable carcinogen by IRAC
1) Data from Cr +6 was used.

TABLE S-33 CHRONIC HAZARDOUS INDEX ESTIMATE - SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects

Site 4, Third Fire Training Area, Alpena CRTIC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Children Chemical- Specific Risk	Total Pathway Risk
Trichloroethylene	1.17E-07	3.04E-07	NO	0.00735	Red blood cells	CA EPA 92	1	2E-05	4E-05	1E-04
Selenium, dissolved	5.129E-07	1.330E-06	NO	0.005	Clinical Selenosis	IRIS, 1993	1	1E-04	3E-04	
Carbon Tetrachloride	1.978E-08	5.129E-08	NO	0.0007	Liver Lesions	IRIS, 1993	1	3E-05	7E-05	2E-06
Tetrachloroethylene	7.083E-09	1.836E-08	NO	0.01	Hepatotoxicity	IRIS, 1993	1	7E-07	2E-06	
Arsenic	4.885E-10	1.268E-09	NO	0.0003	Keratoses	IRIS, 1993	1	2E-06	4E-06	3E-08
Benzene	3.788E-07	9.821E-07	NO	NA	NA	NA	NA	1E-08	3E-08	
Styrene	2.442E-09	6.332E-09	NO	0.2	Red blood cell and liver	IRIS, 1993	1	NA	NA	2E-07
1,2 Dichloroethane	2.442E-09	6.332E-09	NO	No Data	NA	NA	NA	8E-08	2E-07	
1,4 Dichlorobenzene	2.564E-08	6.648E-08	NO	No Data	NA	NA	NA	NA	NA	4E-04
2 Methylnaphthalene	2.442E-09	6.332E-09	NO	0.03	NA	NA	NA	NA	NA	
Lead	9.768E-10	2.533E-09	NO	No Data	NA	NA	NA	NA	NA	
Total										4E-04

TABLE S-34 CANCER ESTIMATE - SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects Site 4, Third Fire Training Area, Alpena CRTG, Alpena, MI											
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	CDI (mg/kg-day) ^{a,1}	SF *	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Children Chemical- Specific Risk	Total Pathway Risk
Trichloroethylene	8.122E-06	8.662E-06	YES	YES	1.76E-02	B2	Lung	CA EPA 92 (1)	1E-07	2E-07	3E-07
Selenium, dissolved	1.185E-07	1.263E-07	YES	YES	NO EVIDENCE		NA		0E+00	0E+00	
Carbon Tetrachloride	6.031E-08	6.431E-08	YES	YES	1.44E-01	B2	Heptocellular carcinomas	IRIS 93	0E+00	0E+00	
Tetrachloroethylene	3.926E-07	4.187E-07	YES	YES	0.051	B2	Liver	CA EPA 92	9E-09	9E-09	
Arsenic	6.769E-11	7.218E-11	YES	YES	1.89E+00	A	Skin, Lung	IRIS 93	2E-08	2E-08	
Benzene	5.249E-06	5.598E-06	YES	YES	0.029	A	Leukemia	IRIS 93	1E-10	1E-10	
Styrene	2.843E-10	3.032E-10	YES	YES	NO DATA	NA	NA	NA	2E-07	2E-07	
1,2 Dichloroethane	1.794E-09	1.913E-09	YES	YES	0.091	B2	Hemangiosarcomas	IRIS 93	2E-10	2E-10	
1,4 Dichlorobenzene	2.203E-07	2.350E-07	YES	YES	0.024	C	Liver tumors	heast 93	5E-09	6E-09	
2 Methylanthralene	3.384E-10	3.609E-10	YES	YES	NO EVIDENCE	NA	NA	NA	0E+00	0E+00	
Lead	5.415E-13	5.775E-13	YES	YES	NO DATA	B2	Kidney	NA	0E+00	0E+00	
total											4E-07

* Adjusted from administered to absorbed dose by assuming the following oral absorption efficiencies: Se 0.935 (ASTDR, 1989), As 0.95 (ASTDR(1991), CCl4 0.9 (ASTDR, 1992), PCE 1.0 (ASTDR 1990), Benzene 1.0 (ASTDR 1989), Styrene 1.0 (default), TCE 0.85 (default), 1,2 DCE 1.0 (default), 1,4 DCB 1.0 (ASTDR 1991).

TABLE S-35 CHRONIC HAZARDOUS INDEX ESTIMATE - SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects

Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Children Chemical- Specific Risk	Total Pathway Risk
Trichloroethylene	2.274E-05	4.042E-05	YES	0.85	Red blood cells	CA EPA 92	1	3E-05	5E-05	8E-04
Selenium, dissolved	3.317E-07	5.895E-07	YES	0.004675	Clinical Selenosis	IRIS, 1993	1	7E-05	1E-04	
Carbon Tetrachloride	1.689E-07	3.001E-07	YES	0.00063	Liver Lesions	IRIS, 1993	1	3E-04	5E-04	
Tetrachloroethylene	1.095E-06	1.954E-06	YES	0.01	Hepatotoxicity	IRIS, 1993	1	1E-04	2E-04	
Arsenic	1.895E-10	3.368E-10	YES	0.000285	Keratosis	IRIS, 1993	1	7E-07	1E-06	
Benzene	1.470E-05	2.612E-05	YES	No Data	NA	NA	NA	NA	7E-09	
Styrene	7.960E-10	1.415E-09	YES	0.2	Red blood cell and liver	IRIS, 1993	1	4E-09	NA	
1,2 Dichloroethane	5.022E-09	8.927E-09	YES	No Data	NA	NA	NA	NA	NA	
1,4 Dichlorobenzene	6.169E-07	1.096E-06	YES	No Data	NA	NA	NA	NA	NA	
2 Methyl naphthalene	9.476E-10	1.684E-09	YES	0.03	NA	NA	NA	3E-08	6E-08	
Lead	1.516E-12	2.695E-12	YES	No Data	NA	NA	NA	NA	NA	
								5E-04		8E-04

* Adjusted from administered to absorbed dose by assuming the following oral absorption efficiencies: Se 0.935 (ASTDR, 1989), As 0.95 (ASTDR(1991), CCl4 0.9 (ASTDR, 1992), PCE 1.0 (ASTDR 1990), Benzene 1.0 (ASTDR 1989), Styrene 1.0 (default), TCE 0.85 (default)

1,2 DCE 1.0 (default), 1,4 DCB 1.0 (ASTDR 1991).

1) RfD calculated from conversion of 1.3 mg/L drinking water standard.

Groundwater Solute Transport Model Data - Site 4

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.
2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.
3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.
4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.
5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.

6. Vertical variations in head and concentrations are negligible.
7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft²/day at TF4-MW3 to 15,290 ft²/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and

Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^n (h_m - h_s)^2]^{0.5}$$

n = number of wells
 h_m = measured head
 h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = $128.78/38 = 3.3891$
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

- * The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).
- * The initial head data input to the transport model are results of measurements taken in September 1993.
- * Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.
- * Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.
- * The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.
- * The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 4

No organic compounds were present in the groundwater at Site 4 above Act 307 Type B cleanup criteria. However, model simulations predict that contaminants from sites 2, 5, 6, 8, and 9 would reach the sinkhole after a period of several years with maximum concentrations entering the sinkhole between 5 and 20 years depending on which site the contaminants originate from. PCE, arsenic, and carbon tetrachloride originating from wells MP2MW7, MP2MW1 and PW3 at Site 2 arrive at the sinkhole in concentrations ranging from 0.002 (arsenic) to 0.28 ug/l for PCE. The chemicals 1,2 -DCA, 1,4 -DCB, benzene and styrene originating from well SF5MW1 at Site 5 arrive at the sinkhole at concentrations ranging from 0.01 (styrene) and 1.55 ug/l for benzene. Well LF6MW3 at Site 6 contained carbon tetrachloride which arrived at the sinkhole at an estimated concentration of 0.08 ug/l. Well HN8MW3 at Site 8 contained PCE which arrived at the sinkhole with an estimated concentration of 0.001 ug/l. Well RT9MW6 at Site 9 contained PCE, benzene, 1,4 -DCB, lead, and 2-methylnapthalene which arrived at the sinkhole at concentrations ranging from 0.001 (PCE) to 0.01 ug/l for 2-methylnapthlene.

Appendix T: Site 5 Risk Assessment

Table T-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 5
MIANG, Alpena CRT, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-SF5	MW1	PC-SF5-MW1-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW2	PC-SF5-MW2-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW3	PC-SF5-MW3-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW4	PC-SF5-MW4-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW5	PC-SF5-MW5-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW6	PC-SF5-MW6-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW7	PC-SF5-MW7-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW8	PC-SF5-MW8-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW9	PC-SF5-MW9-GW4	GROUNDWATER	1,2-Dichloroethane	0.4400
PC-SF5	MW1	PC-SF5-MW1-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW2	PC-SF5-MW2-GW4	GROUNDWATER	1,4-Dichlorobenzene	3.5000
PC-SF5	MW3	PC-SF5-MW3-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW4	PC-SF5-MW4-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW5	PC-SF5-MW5-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW6	PC-SF5-MW6-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW7	PC-SF5-MW7-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW9	PC-SF5-MW9-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW1	PC-SF5-MW1-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW2	PC-SF5-MW2-GW4	GROUNDWATER	Benzene	52.0000
PC-SF5	MW3	PC-SF5-MW3-GW4	GROUNDWATER	Benzene	0.1750
PC-SF5	MW4	PC-SF5-MW4-GW4	GROUNDWATER	Benzene	0.1750
PC-SF5	MW5	PC-SF5-MW5-GW4	GROUNDWATER	Benzene	0.1750
PC-SF5	MW6	PC-SF5-MW6-GW4	GROUNDWATER	Benzene	0.1750
PC-SF5	MW7	PC-SF5-MW7-GW4	GROUNDWATER	Benzene	0.1750
PC-SF5	MW8	PC-SF5-MW8-GW4	GROUNDWATER	Benzene	0.1750
PC-SF5	MW9	PC-SF5-MW9-GW4	GROUNDWATER	Benzene	41.0000
PC-SF5	MW1	PC-SF5-MW1-GW4	GROUNDWATER	Benzene	0.2600
PC-SF5	MW2	PC-SF5-MW2-GW4	GROUNDWATER	Styrene	1.5000
PC-SF5	MW3	PC-SF5-MW3-GW4	GROUNDWATER	Styrene	0.1250
PC-SF5	MW4	PC-SF5-MW4-GW4	GROUNDWATER	Styrene	0.1250
PC-SF5	MW5	PC-SF5-MW5-GW4	GROUNDWATER	Styrene	0.1250
PC-SF5	MW6	PC-SF5-MW6-GW4	GROUNDWATER	Styrene	0.1250
PC-SF5	MW7	PC-SF5-MW7-GW4	GROUNDWATER	Styrene	0.1250
PC-SF5	MW8	PC-SF5-MW8-GW4	GROUNDWATER	Styrene	0.1250
PC-SF5	MW9	PC-SF5-MW9-GW4	GROUNDWATER	Styrene	0.6700
PC-SF5	MW1	PC-SF5-MW1-GW4	GROUNDWATER	Styrene	0.1250

TABLE T-1 EXPOSURE ASSESSMENT PARAMETERS - FISH INGESTION
Site 6, Second Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Fraction of Fish Ingested, unitless	0.5	0.5
Ingestion rate kg/day	0.054	0.043
Exposure Frequency days/yr	26	26
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

**TABLE T-2 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO**

Noncarcinogenic Effect Exposure Assessment
Site 5, Second Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Styrene	1.000E-03	0.054	26	0.5	25	70	9125	2.748E-08
Benzene	3.600E-02	0.054	26	0.5	25	70	9125	9.891E-07
1,4-Dichlorobenzene	6.000E-03	0.054	26	0.5	25	70	9125	1.649E-07
1,2-Dichloroethane	2.000E-02	0.054	26	0.5	25	70	9125	5.495E-07

**TABLE T-3 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO**

Noncarcinogenic Effect Exposure Assessment
Site 5, Second Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Styrene	1.000E-03	0.043	26	0.5	15	27	5475	5.672E-08
Benzene	3.600E-02	0.043	26	0.5	15	27	5475	2.042E-06
1,4-Dichlorobenzene	6.000E-03	0.043	26	0.5	15	27	5475	3.403E-07
1,2-Dichloroethane	2.000E-02	0.043	26	0.5	15	27	5475	1.134E-06

**TABLE T-4 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO**

Carcinogenic Effect Exposure Assessment
Site 5, Second Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Styrene	1.000E-03	0.054	26	0.5	25	70	25550	9.813E-09
Benzene	3.600E-02	0.054	26	0.5	25	70	25550	3.533E-07
1,4-Dichlorobenzene	6.000E-03	0.054	26	0.5	25	70	25550	5.888E-08
1,2-Dichloroethane	2.000E-02	0.054	26	0.5	25	70	25550	1.963E-07

**TABLE T-5 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO**

Carcinogenic Effect Exposure Assessment
Site 5, Second Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Styrene	1.000E-03	0.043	26	0.5	15	27	25550	1.215E-08
Benzene	3.600E-02	0.043	26	0.5	15	27	25550	4.376E-07
1,4-Dichlorobenzene	6.000E-03	0.043	26	0.5	15	27	25550	7.293E-08
1,2-Dichloroethane	2.000E-02	0.043	26	0.5	15	27	25550	2.431E-07

TABLE T-8 CANCER ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects

Site 5, Second Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	CDI Adjusted for Absorption (mg/kg-day) ^a -1	SF	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Styrene	9.81E-08	1.21E-08	NO	NO EVIDENCE	1			IRIS, 1993	0E+00		0E+00	
Benzene	3.53E-07	4.37E-07	NO	0.029		A	Leukemia	HEAST 93	1E-08		1E-08	
1,4-Dichlorobenzene	5.88E-08	7.29E-08	NO	0.029		C	Liver Tumors	IRIS, 1993	2E-09		2E-09	
1,2-Dichloroethane	1.96E-07	2.43E-07	NO	0.13		B2	Hemangiosarcomas		3E-08	4E-08	3E-08	5E-08

TABLE T-7 CHRONIC HAZARDOUS INDEX ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects

Site 5, Second Fire Training Area, Alpena GRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	CDI (mg/kg-day)	RD (mg/kg-day)	Critical Effect	RD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Styrene	2.748E-08	5.672E-08	NO	NO	0.2	Red blood cell, Liver	IRIS, 1993	1	1E-07		3E-07	
Benzene	9.891E-07	2.042E-06	NO	NO	NO DATA	NA						
1,4-Dichlorobenzene	1.648E-07	3.403E-07	NO	NO	NO DATA	NA						
1,2-Dichloroethane	5.495E-07	1.134E-06	NO	NO	NO DATA	NA				1E-07		3E-07

Groundwater Solute Transport Model Data - Site 5

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.
2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.
3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.
4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.
5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.
6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft²/day at TF4-MW3 to 15,290 ft²/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^n (h_m - h_s)^2]^{0.5}$$

n = number of wells

h_m = measured head

h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76
S1MW3	13,27 -	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW12	16,25	674.55	675.94	-1.39
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = $128.78/38 = 3.3891$
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

- * The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).
- * The initial head data input to the transport model are results of measurements taken in September 1993.
- * Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.
- * Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.
- * The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.
- * The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 5

Several chemicals were detected in well SF5MW1 above MDNR Type A or Type B cleanup criteria. These compounds are 1,2- Dichloroethane, 1,4- Dichlorobenzene, Benzene, and Styrene at concentrations of 0.44, 3.5, 52, and 1.5 ug/l, respectively. Chemical data was input to the model and concentrations of the contaminants were monitored along the eastern shore of Lake Winyah and at the sinkhole with respect to time.

Appendix U: Site 6/7 Risk Assessment

Table U-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 6/7
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-LF6	MW1	PC-LF6-MW1-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW10	PC-LF6-MW10-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW2	PC-LF6-MW2-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW3	PC-LF6-MW3-GW4	GROUNDWATER	Carbon Tetrachloride	1.1000
PC-LF6	MW4	PC-LF6-MW4-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW5	PC-LF6-MW5-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW6	PC-LF6-MW6-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW8	PC-LF6-MW8-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW9	PC-LF6-MW9-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750

Table U-2A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Sediment - Site 617
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE	RESULT
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Anthracene	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Anthracene	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Anthracene	0.0000	348.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Benzo(a)anthracene	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Benzo(a)anthracene	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Benzo(a)anthracene	0.0000	343.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Benzo(a)pyrene	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Benzo(a)pyrene	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Benzo(a)pyrene	0.0000	278.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Benzo(b)fluoranthene	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Benzo(b)fluoranthene	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Benzo(b)fluoranthene	0.0000	462.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Benzo(ghi)perylene	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Benzo(ghi)perylene	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Benzo(ghi)perylene	0.0000	148.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Benzo(k)fluoranthene	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Benzo(k)fluoranthene	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Benzo(k)fluoranthene	0.0000	462.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Butyl benzyl phthalate	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Butyl benzyl phthalate	0.0000	510.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Butyl benzyl phthalate	0.0000	60.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Carbazole	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Carbazole	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Carbazole	0.0000	162.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Chromium	0.0000	4.9000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Chromium	0.0000	15.9000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Chromium	0.0000	6.3000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Chrysene	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Chrysene	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Chrysene	0.0000	332.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Copper	0.0000	6.2000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Copper	0.0000	16.4000

Table U-2A (continued)
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Sediment - Site 617
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE	RESULT
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Copper	0.0000	12.8000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Di-n-butyl phthalate	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Di-n-butyl phthalate	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Di-n-butyl phthalate	0.0000	150.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Fluoranthene	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Fluoranthene	0.0000	540.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Fluoranthene	0.0000	442.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Indeno(1,2,3-c,d)pyrene	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Indeno(1,2,3-c,d)pyrene	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Indeno(1,2,3-c,d)pyrene	0.0000	178.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Lead	0.0000	5.3000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Lead	0.0000	177.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Lead	0.0000	40.8000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Nickel	0.0000	5.5500
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Nickel	0.0000	12.7500
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Nickel	0.0000	5.2800
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Phenanthrene	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Phenanthrene	0.0000	310.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Phenanthrene	0.0000	348.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Pyrene	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Pyrene	0.0000	290.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Pyrene	0.0000	328.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Selenium	0.0000	0.4750
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Selenium	0.0000	2.3000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Selenium	0.0000	0.2150

TABLE U-1 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH SEDIMENT
Site 8 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (cm ² /day)	3120	1400
Soil to Skin Adherence Factor (mg/cm ²)	2.77	2.77
Absorption Factor, Unitless		
Metals	0.01	0.01
Organics	0.25	0.25
Exposure Factor (days/year)	48	48
Exposure Duration (year)	25	15
Body Weight (kilograms)	70	27
Conversion Factor	1E-06	1E-06
Averaging Time (years)		
Carcinogens	70	70
Noncarcinogens	25	15

**TABLE U-2 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SEDIMENT
FUTURE LAND USE SCENARIO**

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRT, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Soil to Skin Adherence (mg/cm ²)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Anthracene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Benzo(a)anthracene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Benzo(a)pyrene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Benzo(b)fluoranthene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Benzo(ghi)perylene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Benzo(k)fluoranthene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Butyl benzyl phthalate	5.500E-01	1.00E-06	3120	2.77	0.25	48	25	70	9125	2.232E-06
Carbazole	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Chrysene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Di-n-butyl phthalate	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Fluoranthene	5.500E-01	1.00E-06	3120	2.77	0.25	48	25	70	9125	2.232E-06
Indeno(1,2,3-c,d)pyrene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Lead	1.770E+02	1.00E-06	3120	2.77	0.01	48	25	70	9125	2.874E-05
Phenanthrene	5.500E-01	1.00E-06	3120	2.77	0.25	48	25	70	9125	2.232E-06
Pyrene	5.500E-01	1.00E-06	3120	2.77	0.25	48	25	70	9125	2.232E-06
Selenium	2.300E-00	1.00E-06	3120	2.77	0.01	48	25	70	9125	3.734E-07

**TABLE U-3 DAILY INTAKE - CHILD
DERMAL CONTACT WITH SEDIMENT
FUTURE LAND USE SCENARIO**

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRT, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Soil to Skin Adherence (mg/cm ²)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Anthracene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Benzo(a)anthracene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Benzo(a)pyrene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Benzo(b)fluoranthene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Benzo(ghi)perylene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Benzo(k)fluoranthene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Butyl benzyl phthalate	5.500E-01	1.00E-06	1490	2.77	0.25	48	15	27	5475	2.784E-06
Carbazole	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Chrysene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Di-n-butyl phthalate	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Fluoranthene	5.500E-01	1.00E-06	1490	2.77	0.25	48	15	27	5475	2.784E-06
Indeno(1,2,3-c,d)pyrene	1.150E+00	1.00E-06	1490	2.77	0.01	48	15	27	5475	3.558E-05
Lead	1.770E+02	1.00E-06	1490	2.77	0.25	48	15	27	5475	2.784E-06
Phenanthrene	5.500E-01	1.00E-06	1490	2.77	0.25	48	15	27	5475	2.784E-06
Pyrene	5.500E-01	1.00E-06	1490	2.77	0.25	48	15	27	5475	2.784E-06
Selenium	2.300E-00	1.00E-06	1490	2.77	0.01	48	15	27	5475	4.624E-07

TABLE U-4 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SEDIMENT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTG, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /2/day)	Skin Adherence (mg/cm ²)	Sol to (mg/cm ²)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Anthracene	1.150E+00	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	1.667E-06
Benzo(a)anthracene	1.150E+00	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	1.667E-06
Benzo(a)pyrene	1.150E+00	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	1.667E-06
Benzo(b)fluoranthene	1.150E+00	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	1.667E-06
Benzo(k)fluoranthene	1.150E+00	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	1.667E-06
Butyl benzyl phthalate	5.500E-01	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	7.973E-07
Carbazole	1.150E+00	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	1.667E-06
Chrysene	1.150E+00	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	1.667E-06
Di-n-butyl phthalate	1.150E+00	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	1.667E-06
Fluoranthene	5.500E-01	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	7.973E-07
Indeno(1,2,3-c,d)pyrene	1.150E+00	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	1.667E-06
Lead	1.770E+02	1.0E-06	3120	2.77	2.77	0.01	48	25	70	25550	1.028E-05
Phenanthrene	5.500E-01	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	7.973E-07
Pyrene	5.500E-01	1.0E-06	3120	2.77	2.77	0.25	48	25	70	25550	7.973E-07
Selenium	2.300E+00	1.0E-06	3120	2.77	2.77	0.01	48	25	70	25550	1.334E-07

TABLE U-5 DAILY INTAKE - CHILD
DERMAL CONTACT WITH SEDIMENT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTG, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /2/day)	Skin Adherence (mg/cm ²)	Sol to (mg/cm ²)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Anthracene	1.150E+00	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	1.238E-06
Benzo(a)anthracene	1.150E+00	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	1.238E-06
Benzo(a)pyrene	1.150E+00	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	1.238E-06
Benzo(b)fluoranthene	1.150E+00	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	1.238E-06
Benzo(k)fluoranthene	1.150E+00	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	1.238E-06
Butyl benzyl phthalate	5.500E-01	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	5.923E-07
Carbazole	1.150E+00	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	1.238E-06
Chrysene	1.150E+00	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	1.238E-06
Di-n-butyl phthalate	1.150E+00	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	1.238E-06
Fluoranthene	5.500E-01	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	5.923E-07
Indeno(1,2,3-c,d)pyrene	1.150E+00	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	1.238E-06
Lead	1.770E+02	1.0E-06	1490	2.77	2.77	0.01	48	15	27	25550	7.623E-06
Phenanthrene	5.500E-01	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	5.923E-07
Pyrene	5.500E-01	1.0E-06	1490	2.77	2.77	0.25	48	15	27	25550	5.923E-07
Selenium	2.300E+00	1.0E-06	1490	2.77	2.77	0.01	48	15	27	25550	9.908E-08

TABLE U-6 EXPOSURE ASSESSMENT PARAMETERS - SEDIMENT INGESTION
 Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	RECREATIONAL	
	ADULT	CHILD
Ingestion Rate (mg/day)	100	200
Fraction Ingested from Contaminated Sources (unitless)	1	1
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	6
Body Weight (kilograms)	70	15
Conversion Factor	1E-06	1E-06
Averaging Times (years)	70	70
Carcinogens	25	6
Noncarcinogens		

TABLE U-7 DAILY INTAKE - ADULT
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Anthracene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Benzofluoranthene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Benzofluoranthene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Benzofluoranthene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Benzofluoranthene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Butyl benzyl phthalate	5.500E-01	1E-06	100	1	48	25	70	9125	2.160E-07
Carbazole	1.150E+00	1E-06	100	1	48	25	70	9125	1.033E-07
Chrysene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Di-n-butyl phthalate	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Fluoranthene	5.500E-01	1E-06	100	1	48	25	70	9125	1.033E-07
Iodol(1,2,3-c,d)pyrene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Lead	1.770E+02	1E-06	100	1	48	25	70	9125	3.325E-05
Phenanthrene	5.500E-01	1E-06	100	1	48	25	70	9125	1.033E-07
Pyrene	5.500E-01	1E-06	100	1	48	25	70	9125	1.033E-07
Selenium	2.300E+00	1E-06	100	1	48	25	70	9125	4.321E-07

TABLE U-8 DAILY INTAKE - CHILD
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL CHILD

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Anthracene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Benzofluoranthene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Benzofluoranthene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Benzofluoranthene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Butyl benzyl phthalate	5.500E-01	1E-06	200	1	48	6	15	2190	9.644E-07
Carbazole	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Chrysene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Di-n-butyl phthalate	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Fluoranthene	5.500E-01	1E-06	200	1	48	6	15	2190	9.644E-07
Iodol(1,2,3-c,d)pyrene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Lead	1.770E+02	1E-06	200	1	48	6	15	2190	3.104E-04
Phenanthrene	5.500E-01	1E-06	200	1	48	6	15	2190	9.644E-07
Pyrene	5.500E-01	1E-06	200	1	48	6	15	2190	9.644E-07
Selenium	2.300E+00	1E-06	200	1	48	6	15	2190	4.033E-06

TABLE U-9 DAILY INTAKE - ADULT
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRT, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Adult Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Anthracene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Benzol(a)anthracene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Benzol(b)fluoranthene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Benzol(k)fluoranthene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Butyl benzyl phthalate	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Carbazole	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Chrysene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Di-n-butyl phthalate	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Fluoranthene	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Indeno(1,2,3-c,d)pyrene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Lead	1.770E+02	1E-06	100	1	48	25	70	25550	1.188E-05
Phenanthrene	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Pyrene	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Selenium	2.300E+03	1E-06	100	1	48	25	70	25550	1.543E-07
Fluoranthene	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Indeno(1,2,3-c,d)pyrene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Lead	1.770E+02	1E-06	100	1	48	25	70	25550	1.188E-05
Phenanthrene	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Pyrene	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Selenium	2.300E+03	1E-06	100	1	48	25	70	25550	1.543E-07

TABLE U-10 DAILY INTAKE - CHILD
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL CHILD

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRT, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Child Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Anthracene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Benzol(a)anthracene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Benzol(b)fluoranthene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Benzol(k)fluoranthene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Butyl benzyl phthalate	5.500E-01	1E-06	200	1	48	6	15	25550	8.268E-08
Carbazole	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Chrysene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Di-n-butyl phthalate	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Fluoranthene	5.500E-01	1E-06	200	1	48	6	15	25550	8.268E-08
Indeno(1,2,3-c,d)pyrene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Lead	1.770E+02	1E-06	200	1	48	6	15	25550	2.660E-05
Phenanthrene	5.500E-01	1E-06	200	1	48	6	15	25550	8.268E-08
Pyrene	5.500E-01	1E-06	200	1	48	6	15	25550	8.268E-08
Selenium	2.300E+03	1E-06	200	1	48	6	15	25550	3.457E-07
Phenanthrene	5.500E-01	1E-06	200	1	48	6	15	25550	8.268E-08
Pyrene	5.500E-01	1E-06	200	1	48	6	15	25550	8.268E-08
Selenium	2.300E+03	1E-06	200	1	48	6	15	25550	3.457E-07

TABLE U-11 EXPOSURE ASSESSMENT PARAMETERS - FISH INGESTION
 Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Fraction of Fish Ingested, unitless	0.5	0.5
Ingestion rate kg/day	0.054	0.043
Exposure Frequency days/yr	26	26
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE U-12 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical * Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.700E-04	0.054	26	0.5	25	70	9125	4.671E-09

* Concentration adjusted from surface water concentration to fish concentration by bioconcentration factor of 17

TABLE U-13 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical * Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.700E-04	0.043	26	0.5	15	27	5475	9.643E-09

* Concentration adjusted from surface water concentration to fish concentration by bioconcentration factor of 17

TABLE U-14 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical * Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.700E-04	0.054	26	0.5	25	70	25550	1.668E-09

* Concentration adjusted from surface water concentration to fish concentration by bioconcentration factor of 17

TABLE U-15 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical * Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.700E-04	0.043	26	0.5	15	27	25550	2.066E-09

* Concentration adjusted from surface water concentration to fish concentration by bioconcentration factor of 17

TABLE U-16 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF SURFACE WATER
 Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTG, Alpena, MI

PARAMETER	ADULT	CHILD
Exposure Time (hrs/day)	26	26
Surface Water Contact Rate (ml/hr)	50	50
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE U-17 DAILY INTAKE - ADULT
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.000E-05	0.050	48	2.6	25	70	9125	2.442E-09

TABLE U-18 DAILY INTAKE - CHILD
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.000E-05	0.050	48	2.6	15	27	5475	6.332E-09

TABLE U-19 DAILY INTAKE - ADULT
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.000E-05	0.050	48	2.6	25	70	25550	8.722E-10

TABLE U-20 DAILY INTAKE - CHILD
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.000E-05	0.050	48	2.6	15	27	25550	1.357E-09

TABLE U-21 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH THUNDERBAY RIVER SURFACE WATER
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	2.6	2.6
Dermal Permeability Constant	0.00084	0.00084
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	0.001

TABLE U-22 DAILY INTAKE - ADULT
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	(b)	1.000E-05	0.022	19400	48	2.6	25	9125	0.001	2.085E-08

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

TABLE U-23 DAILY INTAKE - CHILD
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	(b)	1.000E-05	0.022	13300	48	2.6	15	5475	0.001	3.705E-08

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

TABLE U-24 DAILY INTAKE - ADULT
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment

Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	(b) 1.000E-05	0.022	19400	48	2.6	25	70	25550	0.001	7.445E-09

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

TABLE U-25 DAILY INTAKE - CHILD
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment

Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	(b) 1.000E-05	0.022	13300	48	2.6	15	27	25550	0.001	7.940E-09

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

TABLE U-26 CANCER ESTIMATE - SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT AND CHILD

Carcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRI/C, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Evidence	Weight of Relative Potency Factor	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Anthracene	7.716E-08	1.728E-07	NO	NO EVIDENCE	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Benzofluoranthene	7.716E-08	1.728E-07	NO	7.3	7.3	B2 / 0.1	Liver and Lung	(a)	6E-08		1E-07	
Benzofluoranthene	7.716E-08	1.728E-07	NO	7.3	7.3	B2 / 1.0	Fore Stomach	(a)	6E-07		1E-06	
Benzofluoranthene	7.716E-08	1.728E-07	NO	NO EVIDENCE	NO EVIDENCE	NA	Lung, thorax, liver	NA	0E+00		0E+00	
Benzofluoranthene	7.716E-08	1.728E-07	NO	7.3	7.3	B2 / 0.01	Lung, thorax, liver	(a)	6E-08		1E-08	
Butyl benzyl phthalate	3.690E-08	8.266E-08	NO	NO EVIDENCE	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Carbazole	7.716E-08	1.728E-07	NO	NO EVIDENCE	NO EVIDENCE	NA	Liver, lung	NA	0E+00		0E+00	
Chrysene	7.716E-08	1.728E-07	NO	7.3	7.3	B2 / 0.001	NA	(a)	6E-10		1E-09	
Di n-butyl phthalate	3.690E-08	8.266E-08	NO	NO EVIDENCE	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Fluoranthene	7.716E-08	1.728E-07	NO	NO EVIDENCE	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Indeno(1,2,3-c,d)pyrene	1.188E-05	2.666E-05	NO	7.3	7.3	B2 / 0.1	NA	(a)	6E-08		1E-07	
Lead	3.690E-08	8.266E-08	NO	NO DATA	NO DATA	NA	NA	NA	0E+00		0E+00	
Phenanthrene	3.690E-08	8.266E-08	NO	NO EVIDENCE	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Pyrene	3.690E-08	8.266E-08	NO	NO EVIDENCE	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Selenium	1.543E-07	3.457E-07	NO	NO EVIDENCE	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Total									7E-07		2E-06	

TABLE U-27 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT AND CHILD

Noncarcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRT, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	Chronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Child Chemical- Specific Risk	Total Pathway Risk
Anthracene	2.16E-07	2.02E-06	NO	0.3	No observed effects	IRIS 93	1	7E-07		7E-06	
Benzofluoranthrene	2.16E-07	2.02E-06	NO	0.03	NA	(a)	1	7E-06		7E-05	
Benzofluoranthrene	2.16E-07	2.02E-06	NO	0.03	NA	(a)	1	7E-06		7E-05	
Benzofluoranthrene	2.16E-07	2.02E-06	NO	0.03	NA	(a)	1	7E-06		7E-05	
Benzofluoranthrene	2.16E-07	2.02E-06	NO	0.03	NA	(a)	1	7E-06		7E-05	
Butyl benzyl phthalate	1.03E-07	9.64E-07	NO	NOT AVAILABLE	NA	NA	1	7E-06		7E-05	
Chrysene	2.16E-07	2.02E-06	NO	NOT AVAILABLE	NA	NA	NA				
Di-n-butyl phthalate	2.16E-07	2.02E-06	NO	NA	NA	NA	1	2E-06		2E-05	
Fluoranthene	1.03E-07	9.64E-07	NO	0.1	Increased mortality	IRIS 93	1	3E-06		2E-05	
Indene(1,2,3-c,d)pyrene	2.16E-07	2.02E-06	NO	0.04	Neuropathy	IRIS 93	1	7E-06		7E-05	
Lead	3.33E-05	3.10E-04	NO	NO DATA	NA	NA	NA				
Phenanthrene	1.03E-07	9.64E-07	NO	0.03	NA	NA	NA	3E-06		3E-05	
Pyrene	1.03E-07	9.64E-07	NO	0.03	NA	NA	NA	3E-06		3E-05	
Selenium	4.32E-07	4.03E-06	NO	0.005	Clinical Scleriosis	IRIS 93	NA	9E-05		8E-04	
Total									1E-04		1E-03

(a) Chronic RfD for pyrene was used. Source IRIS 93

TABLE U-28 CANCER ESTIMATE - DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO

Carcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTIC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	SF	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Child Total Chemical Pathway Specific Risk	Total Pathway Risk
Anthracene	1.667E-06	1.238E-06	YES	NO EVIDENCE	NA	NA	NA	0.000E+00	0.000E+00	
Benzo(a)anthracene	1.667E-06	1.238E-06	YES	43	B2 / 0.1	Liver and Lung	(a)	7.169E-06	5.325E-06	
Benzo(a)pyrene	1.667E-06	1.238E-06	YES	43	B2 / 0.1	Fore Stomach	(a)	7.169E-05	5.325E-05	
Benzo(b)fluoranthene	1.667E-06	1.238E-06	YES	43	NA	Lung, thorax, liver	(a)	7.169E-06	5.325E-06	
Benzo(k)fluoranthene	1.667E-06	1.238E-06	YES	NO EVIDENCE	NA	NA	NA	7.169E-05	5.325E-05	
Butyl benzyl phthalate	7.973E-07	5.923E-07	YES	NO EVIDENCE	B2 / 0.01	Lung, thorax, liver	(a)	3.428E-05	2.547E-05	
Carbazole	1.667E-06	1.238E-06	YES	11	NA	NA	NA	0.000E+00	0.000E+00	
Chrysene	1.667E-06	1.238E-06	YES	NO EVIDENCE	B2 / 0.001	Liver, lung	(a)	1.834E-08	1.362E-08	
d,n-butyl phthalate	7.973E-07	5.923E-07	YES	NO EVIDENCE	NA	NA	NA	0.000E+00	0.000E+00	
fluoranthene	1.667E-06	1.238E-06	YES	43	NA	NA	NA	0.000E+00	0.000E+00	
Indeno(1,2,3-c,d)pyrene	1.026E-05	7.625E-06	YES	NO DATA	B2 / 0.1	NA	(a)	7.169E-06	5.325E-06	
Lead	7.973E-07	5.923E-07	YES	NO EVIDENCE	NA	NA	NA	0.000E+00	0.000E+00	
Phenanthrene	7.973E-07	5.923E-07	YES	NO EVIDENCE	NA	NA	NA	0.000E+00	0.000E+00	
Pyrene	7.973E-07	5.923E-07	YES	NO EVIDENCE	NA	NA	NA	0.000E+00	0.000E+00	
Selenium	1.334E-07	9.908E-08	YES	NO EVIDENCE	NA	NA	NA	0.000E+00	0.000E+00	
Total								2E-04	1E-04	

a) SF for pyrene used for all PAHs.
Adjusted from administered to absorbed dose assuming oral absorption efficiencies Chrysene 0.67(ASTDR, 1990), all PAHs 0.17 (ASTDR 1990), di-n-butyl phthalate 0.8 (ASTDR 1990), Se 0.935 (ASTDR 1989)

TABLE U-29 CANCER ESTIMATE - DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTG, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Adult Pathway Risk	Child Chemical-Specific Risk	Child Pathway Risk	Total Pathway Risk
Anthracene	4.66E-06	5.77E-06	YES	0.05	No observed effects	IRIS 93	1	9.33E-05		1.15E-04		
Benzo(a)anthracene	4.66E-06	5.77E-06	YES	0.005	NA	(a)	1	9.33E-04		1.15E-03		
Benzo(b)fluoranthene	4.66E-06	5.77E-06	YES	0.005	NA	(a)	1	9.33E-04		1.15E-03		
Benzo(k)fluoranthene	4.66E-06	5.77E-06	YES	0.005	NA	(a)	1	9.33E-04		1.15E-03		
Benzo(a)pyrene	4.66E-06	5.77E-06	YES	0.005	NA	(a)	1	9.33E-04		1.15E-03		
Butyl benzyl phthalate	2.23E-06	2.76E-06	YES	0.005	NA	NA	NA	4.46E-04		5.52E-04		
Carbazole	4.66E-06	5.77E-06	YES	0.02	NA	NA	NA	2.33E-04		2.89E-04		
Chrysene	4.66E-06	5.77E-06	YES	0.08	Increased mortality	IRIS 93	1	5.83E-05		7.24E-05		
Di-n-butyl phthalate	2.23E-06	2.76E-06	YES	0.007	Neonitropathy	IRIS 93	1	3.19E-04		3.94E-04		
Fluoranthene	4.66E-06	5.77E-06	YES	0.005	NA	(a)	NA	9.33E-04		1.15E-03		
Indeno(1,2,3-c,d)pyrene	2.07E-05	3.55E-05	YES	NO DATA	NA	NA	NA	NA		NA		
Lead	2.23E-06	2.76E-06	YES	0.005	NA	(a)	NA	4.46E-04		5.52E-04		
Phenanthrene	2.23E-06	2.76E-06	YES	0.005	NA	(a)	NA	4.46E-04		5.52E-04		
Pyrene	2.23E-06	2.76E-06	YES	0.005	NA	(a)	NA	4.46E-04		5.52E-04		
Selenium	3.73E-07	4.62E-07	YES	0.005	Clinical Sclerosis	IRIS 93	NA	7.46E-05	7.72E-03	9.24E-05	9.58E-03	
Total												9.58E-03

Adjusted from administered to absorbed dose assuming oral absorption efficiencies Chrysene 0.67 (ASTDR, 1999), all PAHs 0.17 (ASTDR, 1999), di-n-butyl phthalate 0.3 (ASTDR, 1999), Se 0.935 (ASTDR, 1989)
a) Chronic RfD for pyrene used for all PAHs.

TABLE U-30 CANCER ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects									
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena, CRTC, Alpena, MI									
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption (mg/kg-day)	CDI	SF	Weight of Evidence	Type of Cancer	SF Source IRIS, 1993	Children Chemical-Specific Risk
Carbon Tetrachloride	1.688E-09	2.066E-09	NO	NO	0.13	E2	hepatocellular carcinomas	IRIS, 1993	2.686E-10
Total									2.686E-10
									2.169E-10
									2.686E-10

TABLE U-31 CHRONIC HAZARDOUS INDEX ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects											
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTG, Alpena, MI											
Chemical	Adult CDI (mg/kg/day)	Child CDI (mg/kg/day)	Adjusted for Absorption	CM	RfD (mg/kg/day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Child Chemical- Specific Risk	Total Pathway Risk
Carbon Tetrachloride	4.671E-09	9.643E-09		NO	0.0007	Liver	IRIS, 1993	1	6.673E-06	1.378E-05	6.673E-06
											1.378E-05

TABLE U-32 CANCER ESTIMATE - SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects

Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult -CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	CDI	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Carbon Tetrachloride	8.72E-10	1.357E-09	NO	NO	0.13	B2	hepatocellular carcinomas	IRIS, 1993	1.134E-10	1.134E-10	1.704E-10	1.704E-10

TABLE U-33 CHRONIC HAZARDOUS INDEX ESTIMATE - SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects											
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTIC, Alpena, MI											
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	CDI	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Children Chemical- Specific Risk	Total Pathway Risk
Carbon Tetrachloride	2.442E-09	6.332E-09	NO	NO	0.0007	Liver	IRIS, 1993	1	3.489E-06	9.045E-06	3.489E-06
											9.045E-06

TABLE U-34 CANCER ESTIMATE - SURFACE WATER DERMAL
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects

Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	CDI	SF *	Weight of Evidence	Type of Cancer	SF Source IRIS, 1993	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Carbon Tetrachloride	7.44E-09	7.940E-09	YES		(mg/kg-day): 1 1.44E-01	B2	hepatocellular carcinomas	IRIS, 1993	1.075E-09		1.147E-09	
Total									1.075E-09		1.147E-09	

* Adjusted from administered to absorbed dose using and efficiency of 0.90 (ATDSP, 1992).

TABLE U-35 CHRONIC HAZARDOUS INDEX ESTIMATE - SURFACE WATER DERMAL
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Nonscarcinogenic Effects

Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTG, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI * Adjusted for Absorption	RfD * (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Children Chemical- Specific Risk	Total Pathway Risk
Carbon Tetrachloride	2.045E-08	3.705E-08	YES	0.00063	Liver	IRIS, 1993	1	3.309E-05	5.882E-05	5.882E-05

* Adjusted from administered to absorbed dose using and efficiency of 0.90 (ATDSE, 1992).

Groundwater Solute Transport Model Data - Site 6/7

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.
2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.
3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.
4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.
5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.
6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft²/day at TF4-MW3 to 15,290 ft²/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3-dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^n (h_m - h_s)^2]^{0.5}$$

n = number of wells

h_m = measured head

h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = $128.78/38 = 3.3891$

Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

- * The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).
- * The initial head data input to the transport model are results of measurements taken in September 1993.
- * Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.
- * Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.
- * The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.
- * The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 6

Carbon Tetrachloride was present in LF6MW3 above MDNR Type B cleanup criteria at a concentration of 1.2 ug/l. This data was input to the model and concentrations were monitored along the backwater area of Lake Winyah and at the sinkhole with respect to time.

Appendix V: Site 8 Risk Assessment

Table V-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 8
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-HN8	MW1	PC-HN8-MW1-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-HN8	MW2	PC-HN8-MW2-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-HN8	MW3	PC-HN8-MW3-GW4	GROUNDWATER	Tetrachloroethylene	1.2000
PC-HN8	MW4	PC-HN8-MW4-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-HN8	MW5	PC-HN8-MW5-GW4	GROUNDWATER	Tetrachloroethylene	0.1500

Table V-2A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Soil - Site 8
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE	RESULT
PC-HN8	SB4	PC-HN8-SB4-SS00-02	SOIL	Antimony	0.0000 2.0000	2.3500
PC-HN8	SB6	PC-HN8-SB6-SS00-02	SOIL	Antimony	0.0000 2.0000	5.1000
PC-HN8	SB7	PC-HN8-SB7-SS00-02	SOIL	Antimony	0.0000 2.0000	2.4000
PC-HN8	SB4	PC-HN8-SB4-SS00-02	SOIL	Lead	0.0000 2.0000	2.2000
PC-HN8	SB6	PC-HN8-SB6-SS00-02	SOIL	Lead	0.0000 2.0000	42.6000

TABLE V-1 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF GROUNDWATER
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

PARAMETER	RECREATIONAL	
	ADULT	CHILD
Ingestion Rate (L/day)	2	2
Exposure Frequency (days/year)	298 *	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

*Worst case scenario assumes that the adult is present on-site 250 days /year as a worker and 48 days per year for recreation

TABLE V-2 DAILY INTAKE - ADULT
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	8.077E-04	2	298	25	70	9125	1.884E-05

TABLE V-3 DAILY INTAKE - CHILD
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	8.077E-04	2	48	15	27	5475	7.868E-06

TABLE V-4 DAILY INTAKE - ADULT
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	8.077E-04	2	298	25	70	25550	6.729E-06

TABLE V-5 DAILY INTAKE - CHILD
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	8.077E-04	2	48	15	27	25550	1.686E-06

TABLE V-6 EXPOSURE ASSESSMENT PARAMETERS - INHALATION OF GROUNDWATER
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

PARAMETER	RECREATIONAL	
	ADULT	CHILD
Exposure Time (hours/day)	0.12	0.12
Inhalation Rate (cu m/hr)	0.6	0.6
Exposure Frequency (days/yr)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

*Worst case scenario assumes that the adult is present on-site 250 days /year as a worker and 48 days per year for recreation

TABLE V-7 DAILY INTAKE - ADULT
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	7.630E-03	0.6	298	0.12	25	70	9125	6.407E-06

TABLE V-8 DAILY INTAKE - CHILD
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	7.630E-03	0.6	48	0.12	15	27	5475	2.676E-06

TABLE V-9 DAILY INTAKE - ADULT
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/kg-day)
Tetrachloroethylene	7.630E-03	0.6	298	0.12	25	70	25550	2.288E-06

TABLE V-10 DAILY INTAKE - CHILD
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/kg-day)
Tetrachloroethylene	7.630E-03	0.6	48	0.12	15	27	25550	5.734E-07

TABLE V-11 GROUNDWATER INHALATION MODEL CALCULATIONS
Site 8, Former Site of Hangar 9, Alpena CRTG, Alpena, MI

Chemicals	Chemical Concentration (mg/L)	Fraction Volatilized (unitless)	Water Flow Rate (L/hr)	Showering Post Showering		Bathroom Volume (cu m)	Showering Maximum Contaminant Concen'n in Air (mg/cu m)	During and After Showering MAX Contaminant Concen'n in Air (mg/cu m)
				Duration Period (hr)	Duration Period (hr)			
Tetrachloroethylene	8.077E-04	0.7	750	0.25	0.35	11	9.638E-03	7.630E-03

TABLE V-12 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH GROUNDWATER

Site 8, Former Site of Hangar 9, Alpena CRTG, Alpena, MI

PARAMETER	RECREATIONAL ADULT	RECREATIONAL CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	0.25	0.25
Dermal Permeability Constant *	0.00084 *	0.00084 *
Exposure Frequency (days/year)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	

*Worst case scenario assumes that the adult is present on-site 250 days /year as a worker and 48 days per year for recreation

TABLE V-13 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	* Chemical Concentration (mg/l)	* Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a) 8.077E-04	0.4	19400	298	0.25	25	70	9125	0.001	1.828E-05

* (a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992).

TABLE V-14 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	* Chemical Concentration (mg/l)	* Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a) 8.077E-04	0.4	13300	48	0.25	15	27	5475	0.001	5.232E-06

* (a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992).

TABLE V-15 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	* Chemical Concentration (mg/l)	* Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/kg-day)
Tetrachloroethylene	(a) 8.077E-04	0.4	19400	298	0.25	25	70	25550	0.001	6.527E-06

* (a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992).

TABLE V-16 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	* Chemical Concentration (mg/l)	* Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/kg-day)
Tetrachloroethylene	(a) 8.077E-04	0.4	13300	48	0.25	15	27	25550	0.001	1.121E-06

* (a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992).

TABLE V-17. EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH SOILS
Site 8, Former Site of Hanger 9, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION		ON-SITE		RECREATIONAL	
	WORKER		ADULT		ADULT	CHILD
Skin Surface Area Available for Contact (cm ² /day)	3120		3120		3120	1490
Soil to Skin Adherence Factor (mg/cm ²)	2.77		2.77		2.77	2.77
Absorption Factor, Unitless						
Metals	0.01		0.01		0.01	0.01
Organics	0.25		0.25		0.25	0.25
Exposure Factor (days/year)	250		250		298	48
Exposure Duration (year)	0.08		25		25	15
Body Weight (kilograms)	70		70		70	27
Conversion Factor	1E-06		1E-06		1E-06	
Averaging Time, years	70		70		70	70
Carcinogens	0.08		25		25	15
Noncarcinogens						

Recreational adult assumes the adult works at the recreational area 250 days/yr and participates in recreation another 48 days per year.

TABLE V-18 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SOILS
CURRENT LAND USE SCENARIO - ON-SITE EMPLOYEE

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hanger 9, Alpena CRTG, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Soil to Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.00E-06	3120	2.77	0.01	250	25	70	9125	4.313E-06
Lead	4.260E+01	1.00E-06	3120	2.77	0.01	250	25	70	9125	3.602E-05

TABLE V-19 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SOILS
CURRENT LAND USE SCENARIO - ON-SITE EMPLOYEE

Carcinogenic Effect Exposure Assessment
 Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Soil to	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Arsimony	5.100E+00	1.0E-06	3120	2.77	2.77	0.01	250	25	70	25550	1.540E-06
Lead	4.260E+01	1.0E-06	3120	2.77	2.77	0.01	250	25	70	25550	1.287E-05

**TABLE V-20 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS**

Noncardiogenic Effect Exposure Assessment
Site 8, Former Site of Hanger 9, Alpena, CRIC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Arsimony	5.100E+00	1.00E-06	3120	2.77	0.01	250	0.08	70	29.2	4.313E-06
Lead	4.200E+01	1.00E-06	3120	2.77	0.01	250	0.08	70	29.2	3.602E-05

**TABLE V-21 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS**

Cardiogenic Effect Exposure Assessment
Site 8, Former Site of Harglar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Soil to Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.0E-06	3120	2.77	0.01	250	0.08	70	25550	4.929E-09
Lead	4.260E+01	1.0E-06	3120	2.77	0.01	250	0.08	70	25550	4.117E-08

TABLE V-22 DAILY INTAKE - ADULTS
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT

Noncarcinogenic Effect Exposure Assessment
 Site 8, Former Site of Harglar 9, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Sol to	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.00E-06	3120	2.77	2.77	0.01	298	25	70	9125	5.141E-06
Lead	4.260E+01	1.00E-06	3120	2.77	2.77	0.01	298	25	70	9125	4.294E-05

TABLE V-23 DAILY INTAKE CHILD
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - RECREATIONAL CHILD

Noncarcinogenic Effect Exposure Assessment
 Site 8, Former Site of Harglar 9, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Sol to	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.00E-06	1490	2.77	2.77	0.01	48	15	27	5475	1.023E-06
Lead	4.260E+01	1.00E-06	1490	2.77	2.77	0.01	48	15	27	5475	8.564E-06

TABLE V-24 DAILY INTAKE - ADULTS
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT

Cardiogenic Effect Exposure Assessment
 Site 8, Former Site of Hangar 9, Alpena, CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Soil to Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.0E-06	3120	2.77	0.01	298	25	70	25550	1.836E-06
Lead	4.280E+01	1.0E-06	3120	2.77	0.01	298	25	70	25550	1.534E-05

TABLE V-26 DAILY INTAKE CHILD
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO

Cardiogenic Effect Exposure Assessment
 Site 8, Former Site of Hangar 9, Alpena, CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm ² /day)	Skin Adherence (mg/cm ²)	Soil to Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.0E-06	1490	2.77	0.01	48	15	27	25550	2.187E-07
Lead	4.280E+01	1.0E-06	1490	2.77	0.01	48	15	27	25550	1.835E-06

TABLE V-26 EXPOSURE ASSESSMENT PARAMETERS - SOIL INGESTION
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

PARAMETER	FACILITY EMPLOYEE	EXCAVATION WORKER	RECREATIONAL ADULT	RECREATIONAL CHILD
Ingestion Rate (mg/day)	100	480	100	200
Fraction Ingested from Contaminated Sources (unitless)	1	1	1	1
Exposure Frequency (days/year)	250	250	298	48
Exposure Duration (years)	25	0.08	25	6
Body Weight (kilograms)	70	70	70	15
Conversion Factor	1E-06	1E-06	1E-06	1E-06
Averaging Time, years				
Carcinogens	70	70	70	70
Noncarcinogens	25	0.08	25	8

Recreational adult assumes the adult works at the recreational area 250 days/yr and participates in recreation another 48 days per year.

TABLE V-27 DAILY INTAKE - ADULT
SOIL INGESTION
CURRENT LAND USE SCENARIO - FACILITY EMPLOYEE

Noncarcinogenic Effect Exposure Assessment

Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E+00	1E-06	100	1	250	25	70	8125	4.980E-06
Lead	4.260E+01	1E-06	100	1	250	25	70	8125	4.168E-05

**TABLE V-28 DAILY INTAKE - ADULT
SOIL INGESTION
CURRENT LAND USE SCENARIO - FACILITY EMPLOYEE**

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hanjar 9, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E+00	1E-06	100	1	250	25	70	25550	1.782E-06
Lead	4.260E+01	1E-06	100	1	250	25	70	25550	1.489E-05

TABLE V-29 DAILY INTAKE - ADULT
SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Arsimony	5.100E+00	1E-06	480	1	250	0.08	70	29.2	2.395E-05
Lead	4.260E+01	1E-06	480	1	250	0.08	70	29.2	2.001E-04

TABLE V-30 DAILY INTAKE - ADULT
SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hanjjar 8, Alpena CRTG, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E+00	1E-06	480	1	250	0.08	70	25550	2.737E-08
Lead	4.260E+01	1E-06	480	1	250	0.08	70	25550	2.287E-07

TABLE V-31 DAILY INTAKE - ADULT
SOIL INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Arsimony	5,100E+00	1E-06	100	1	298	25	70	9125	5.948E-06
Lead	4,260E+01	1E-06	100	1	298	25	70	9125	4.969E-05

TABLE V-32 DAILY INTAKE - CHILD
SOIL INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL CHILD

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Arsimony	5,100E+00	1E-06	200	1	48	6	15	2190	8.942E-06
Lead	4,260E+01	1E-06	200	1	48	6	15	2190	7.470E-05

TABLE V-33 DAILY INTAKE - ADULT
SOIL INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT

Carcinogenic Effect Exposure Assessment
 Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Arsimony	5.100E+00	1E-06	100	1	298	25	70	25550	2.124E-06
Lead	4.260E+01	1E-06	100	1	298	25	70	25550	1.776E-05

TABLE V-34 DAILY INTAKE - CHILD
SOIL INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL CHILD

Carcinogenic Effect Exposure Assessment
 Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Arsimony	5.100E+00	1E-06	200	1	48	6	15	25550	7.665E-07
Lead	4.260E+01	1E-06	200	1	48	6	15	25550	6.403E-06

TABLE V-36 EXPOSURE ASSESSMENT PARAMETERS - SOIL INHALATION
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Inhalation Rate, (mg/cu m)	20
Exposure Time (hours/day)	8
Exposure Frequency (days/year)	250
Exposure Duration (years)	0.08
Body Weight (kilograms)	70
Averaging Time (years)	70
Carcinogens	0.08
Noncarcinogens	

**TABLE V-36 DAILY INTAKE - ADULT
SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS**

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Concentration (mg/cu m)	Exposure Duration (years)	Inhalation Rate (cu m/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Weight (kg)	Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E-05	0.08	20	8	250	70	29.2	7.984E-05
Lead	4.260E-04	0.08	20	8	250	70	29.2	6.669E-04

**TABLE V-37 DAILY INTAKE - ADULT
SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS**

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Concentration (mg/cu m)	Exposure Duration (years)	Inhalation Rate (cu m/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Weight (kg)	Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E-05	0.08	20	8	250	70	25550	9.125E-08
Lead	4.260E-04	0.08	20	8	250	70	25550	7.622E-07

TABLE V-38 SOIL INHALATION MODEL CALCULATIONS
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Construction work	
Dust Loading Factor (g/m ³)	600
Conversion Factor	0.001
	g/m ³ mg/g
Computations	
C(i), mg/kg	Antimony
W(i)/W, g/g	5.1
C(air), mg/m ³	5.1E-05
	3.06E-05
	Lead
	42.6
	4.26E-04
	2.56E-04

TABLE V-39 SOIL INHALATION MODEL CALCULATIONS
 Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Construction traffic	
Dust Loading Factor (g/m ³)	400
Conversion Factor	0.001
	g/m ³ mg/g
Computations	
C(l), mg/kg	Antimony
W(i)W, g/g	5.1
C(air), mg/m ³	5.1E-05
	Lead
	42.6
	4.26E-04
	1.70E-04

TABLE V-40 CANCER ESTIMATE - GROUNDWATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects

Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Children Chemical- Specific Risk	Total Pathway Risk
Tetrachloroethylene	6.729E-06	1.688E-06	NO	0.051	B2	Liver	CA EPA, 92	3E-07	9E-08	
Total										3E-07
										9E-08

TABLE V-41 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 8, Former Site of Hangar 9, Alpena CRIC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Tetrachloroethylene	1.884E-05	7.868E-06	NO	0.01 - Hepatotoxicity		IRIS, 1993	1	2E-03		8E-04	
Total									2E-03		8E-04

TABLE V-43. CANCER ESTIMATE - GROUNDWATER INHALATION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects										
Site 8, Former Site of Hangar 8, Alpena CRTC, Alpena, MI										
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Total Pathway Risk	Child Chemical- Specific Risk
Tetrachloroethylene	2.28E-06	5.73E-07	NO	0.0018	B2	Leukemia, Liver	CA EPA, 92	4E-09		1E-09
Total								4E-09		1E-09

TABLE V-44 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INHALATION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	CDI	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Tetrachloroethylene	6.407E-06	2.676E-06	NO	NO	0.01	NA	NA	NA	6E-04	6E-04	3E-04	3E-04
Total										6E-04		3E-04

1) RfD for corresponding chronic oral RfD use.

TABLE V-45 CANCER ESTIMATE - DERMAL CONTACT WITH GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects

Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	SF (mg/kg day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Total Pathway Risk	Child Chemical- Specific Risk	Total Pathway Risk
Tetrachloroethylene	6.527E-06	1.121E-06	YES	0.051	B2	Liver	CA EPA, 92	3E-07		6E-08	
Total									3E-07		6E-08

Adjusted from administered to absorbed using and absorption efficiency of 100%.

TABLE V-46 CHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects Site 8, Former Site of Hanger 9, Alpena CRTIC, Alpena, MI									
Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Child Chemical- Specific Risk
Tetrachloroethylene	1.820E-05	5.232E-06	NO	0.01	Hepatotoxicity	IRIS, 1993	1	2E-03	5E-04
Total								2E-03	5E-04

Adjusted from administered to absorbed using and absorption efficiency of 100%.

TABLE V-27 CANCER ESTIMATE - DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO

Carcinogenic Effects Site 9, Former Site of Hanger 9, Alameda CRTC, Alameda, MI												
Chemical	Excavation		Recreational		Child CRA (mg/kg-dw) 2.15E-07	Adult CRA (mg/kg-dw) 1.89E-06	COI Adjusted Assessment YES	SF (mg/kg-dw) NO EVIDENCE	Weight of Evidence	Type of Cancer	SF Source	Excretion Chemical- Specific Risk OE-HQ
	Worker (mg/kg-dw) 4.92E-09	Child CRA (mg/kg-dw) 2.15E-07	Adult CRA (mg/kg-dw) 1.89E-06	Recreational (mg/kg-dw) 1.89E-06								
Antimony							YES	NO EVIDENCE	B2	Kidney	OE-HQ	OE-HQ
Lead							YES	NO EVIDENCE				
Total												OE-HQ
												OE-HQ
												OE-HQ

TABLE V-48 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effects													
Site B, Former Site of Hanger 9, Alameda CRIC, Alameda, MI													
Chemical	Excavation			CDI	Adjusted for Absorption	Child CDI (mg/kg-day)	Adult CDI (mg/kg-day)	Subchronic RPD (mg/kg-day)	Chronic RPD (mg/kg-day)	Critical Effect	RD Score	Modifying Factor	Excavation Chemical-Specific Risk
	Worker CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adult CDI (mg/kg-day)										Excavation Chemical-Specific Risk
Antimony	4.33E-06	1.02E-05	4.29E-05	YES				0.01	0.01	Respiratory System	HEAST FY93	1	2E-01
Lead	3.82E-05	8.56E-06	4.29E-05	YES				0.01	0.01	Liver	HEAST FY93	1	4E-03
Total													2E-01
													3E-01
													5E-02

RPD adjusted from administered to absorbed data using an absorption efficiency of 5%.

TABLE V-40. CANCER ESTIMATE - DERMAL CONTACT WITH SOILS - ON-SITE EMPLOYEE
CURRENT LAND USE SCENARIO

Carcinogenic Effects
Site 8, Former Site of Hanger 9, Alameda CRTC, Alameda, CA

Chemical in Soils Land	Adult CDI (mg/kg-day) 1.20E-06	CDI Adjusted for Absorption YES	SF (mg/kg-day) ⁻¹ NO EVIDENCE	Weight of Evidence B2	Type of Cancer Kidney	SF Source	Adult Chemical Specific Risk 0E+00	Total Pathway Risk 0E+00
Total								0E+00

TABLE V-36 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH SOILS - ON-SITE EMPLOYEE

CURRENT LAND USE SCENARIO

Noncarcinogenic Effects

Site 9, Former Site of Hazard 9, Alpern CRTG, Alpern, MI

Chemical	Adult CDI (mg/kg-day)	CDI Adjusted for Absorption	Chronic RFD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factors	Chemical-Specific Pathway RfD	Total Pathway RfD
Antimony	4.31E-06	YES	2E-05	Respiratory System	IRIS 93	1	2E-01	
Lead	3.62E-06	YES	0.01	Liver	HEAST FY93	1	4E-03	
Total								2E-01

RfD adjusted from administered to absorbed dose using an absorption efficiency of 5%.

TABLE V-81 CANCER ESTIMATE - SOIL ISOSORPTION
FUTURE LAND USE SCENARIO

SOIL CANCER RISK - SOIL FUTURE LAND USE SCENARIO

Carcinogenic Effects SAR Form 57a-2a of Hanger, D. Applied CRIC, Algonia, WI									
Chemical Activity	Concentration		Field [mg/kg]	Adaptor for Assessment [mg/kg]	SF [mg/kg]	Type of Specific Source	Examination		Total Pathway Risk
	Worker [mg/kg]	Adult [mg/kg]					Specific Risk	General Risk	
Lead	2.2E-07	1.77E-06	0.24E-08	100	100	100	100	100	100

TABLE V-42 CHRONIC AND SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INGESTION
FUTURE LAND USE SCENARIO

[illegible]

No subchronic RFID available as of 12/08/93 Chronic RFID used

TABLE V-44 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INGESTION
CURRENT LAND USE SCENARIO - FACILITY EMPLOYEES

Noncarcinogenic Effects
Site is Former Site of Targor O. Alperne CRIC, Alperne, WI

Chemical	Adult CDL (mg/kg-day)	Adult CDL Absorption	Chronic Exposure (mg/kg-day)	Critical Effect	RfD Conc.	Modifying Factor	Adult Chronic Specific Risk	Total Potential Risk
Asbestos	0.00000	1.0	0.00000	Reduced Lifespan	0.00000	1	0.00000	0.00000
Lead	0.00000	1.0	0.00000	Reduced Lifespan	0.00000	1	0.00000	0.00000
Total								0.00000

TABLE V-55 CANCER ESTIMATE - SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Cardiogenic Effects

Site 9, Former Site of Hanger 9, Alpena CRTC, Alpena, MI

Chemical	Excavation CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Excavation Chemical- Specific Risk	Total Pathway Risk
Antimony	9.125E-03	NO	NO EVIDENCE	R2	NA		0E+00	
Lead	7.622E-07	NO	NO DATA				0E+00	
Total								0E+00

TABLE V-56 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Noncarcinogenic Effects

Site 8, Former Site of Hanger 9, Alpena CRTC, Alpena, MI

Chemical	Excavation CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RID (mg/kg-day)	Critical Effect	RID Source	Modifying Factor	Excavation Chemical Specific Risk	Total Pathway Risk
Antimony	7.984E-05	NO	0.0004	NA	IRIS 93	NA	2E-01	
Lead	6.668E-04	NO	NO DATA	NA		NA		
Total								2E-01

* RID converted for corresponding subchronic oral RID was used.

Groundwater Solute Transport Model Data - Site 8

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.
2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.
3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.
4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.
5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.
6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft²/day at TF4-MW3 to 15,290 ft²/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^n (h_m - h_s)_i^2]^{0.5}$$

n = number of wells

h_m = measured head

h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = $128.78/38 = 3.3891$

Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

- * The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).
- * The initial head data input to the transport model are results of measurements taken in September 1993.
- * Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.
- * Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.
- * The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.
- * The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 8

PCE was present in well HN8MW8 above MDNR Type B cleanup criteria at a concentration of 1.2 ug/l. This data was input to the model and concentrations at the sinkhole were monitored with respect to time.

Appendix W: Site 9 Risk Assessment

Table W-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 9
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-RT9	MW1	PC-RT9-MW1-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-RT9	MW2	PC-RT9-MW2-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-RT9	MW3	PC-RT9-MW3-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-RT9	MW4	PC-RT9-MW4-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-RT9	MW6	PC-RT9-MW6-GW4	GROUNDWATER	1,4-Dichlorobenzene	18.0000
PC-RT9	MW1	PC-RT9-MW1-GW4	GROUNDWATER	2-Methylnaphthalene	2.5000
PC-RT9	MW2	PC-RT9-MW2-GW4	GROUNDWATER	2-Methylnaphthalene	2.5000
PC-RT9	MW3	PC-RT9-MW3-GW4	GROUNDWATER	2-Methylnaphthalene	2.5000
PC-RT9	MW4	PC-RT9-MW4-GW4	GROUNDWATER	2-Methylnaphthalene	2.5000
PC-RT9	MW5	PC-RT9-MW5-GW4	GROUNDWATER	2-Methylnaphthalene	2.5000
PC-RT9	MW6	PC-RT9-MW6-GW4	GROUNDWATER	2-Methylnaphthalene	47.0000
PC-RT9	MW1	PC-RT9-MW1-GW4	GROUNDWATER	Benzene	0.1750
PC-RT9	MW2	PC-RT9-MW2-GW4	GROUNDWATER	Benzene	0.1750
PC-RT9	MW3	PC-RT9-MW3-GW4	GROUNDWATER	Benzene	0.1750
PC-RT9	MW4	PC-RT9-MW4-GW4	GROUNDWATER	Benzene	0.1750
PC-RT9	MW5	PC-RT9-MW5-GW4	GROUNDWATER	Benzene	0.1750
PC-RT9	MW6	PC-RT9-MW6-GW4	GROUNDWATER	Benzene	3.9000
PC-RT9	MW1	PC-RT9-MW1-GW4	GROUNDWATER	Lead, Dissolved	1.0000
PC-RT9	MW2	PC-RT9-MW2-GW4	GROUNDWATER	Lead, Dissolved	1.0000
PC-RT9	MW3	PC-RT9-MW3-GW4	GROUNDWATER	Lead, Dissolved	1.0000
PC-RT9	MW4	PC-RT9-MW4-GW4	GROUNDWATER	Lead, Dissolved	1.0000
PC-RT9	MW5	PC-RT9-MW5-GW4	GROUNDWATER	Lead, Dissolved	1.0000
PC-RT9	MW6	PC-RT9-MW6-GW4	GROUNDWATER	Lead, Dissolved	15.9000
PC-RT9	MW1	PC-RT9-MW1-GW4	GROUNDWATER	Tetrachloroethylene	1.0000
PC-RT9	MW2	PC-RT9-MW2-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-RT9	MW3	PC-RT9-MW3-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-RT9	MW4	PC-RT9-MW4-GW4	GROUNDWATER	Tetrachloroethylene	1.7000
PC-RT9	MW5	PC-RT9-MW5-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-RT9	MW6	PC-RT9-MW6-GW4	GROUNDWATER	Tetrachloroethylene	1.5000

TABLE W-1 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF GROUNDWATER
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Ingestion Rate (L/day)	2	2,000
Exposure Frequency (days/year)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE W-2 DAILY INTAKE - ADULT
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	1.369E-03	2	298	25	70	9125	3.193E-05
2-Methylnaphthalene	2.486E-02	2	298	25	70	9125	5.799E-04
1,4-Dichlorobenzene	1.130E-02	2	298	25	70	9125	2.637E-04
Benzene	3.900E-03	2	298	25	70	9125	9.097E-05
Lead, Dissolved	8.487E-03	2	298	25	70	9125	1.980E-04

TABLE W-3 DAILY INTAKE - CHILD
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	1.369E-03	2.000	48	15	27	5475	1.333E-05
2-Methylnaphthalene	2.486E-02	2.000	48	15	27	5475	2.422E-04
1,4-Dichlorobenzene	1.130E-02	2.000	48	15	27	5475	1.101E-04
Benzene	3.900E-03	2.000	48	15	27	5475	3.799E-05
Lead, Dissolved	8.487E-03	2.000	48	15	27	5475	8.268E-05

TABLE W-4 DAILY INTAKE - ADULT
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	1.369E-03	2	298	25	70	25550	1.140E-05
2-Methylnaphthalene	2.486E-02	2	298	25	70	25550	2.071E-04
1,4-Dichlorobenzene	1.130E-02	2	298	25	70	25550	9.417E-05
Benzene	3.900E-03	2	298	25	70	25550	3.249E-05
Lead, Dissolved	8.487E-03	2	298	25	70	25550	7.071E-05

TABLE W-5 DAILY INTAKE - CHILD
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	1.369E-03	2.000	48	15	27	25550	2.857E-06
2-Methylnaphthalene	2.486E-02	2.000	48	15	27	25550	5.190E-05
1,4-Dichlorobenzene	1.130E-02	2.000	48	15	27	25550	2.359E-05
Benzene	3.900E-03	2.000	48	15	27	25550	8.141E-06
Lead, Dissolved	8.487E-03	2.000	48	15	27	25550	1.772E-05

TABLE W-6 CALCULATIONS FOR GROUNDWATER INHALATION
Site 9, Radar Tower, Alpena CRTG, Alpena, MI

Chemicals	Chemical Concentration (mg/L)	Fraction Volatilized (unitless)	Water Flow Rate (L/hr)	Showering Post Showering Duration Period (hr)	Showering Duration Period (hr)	Bathroom Volume (cu m)	Showering Maximum Contaminant Concen'n in Air (mg/cu m)	During and After Showering MAX Contaminant Concen'n in Air (mg/cu m)
Tetrachloroethylene	1.369E-03	0.7	750	0.25	0.35	11	1.633E-02	1.293E-02
2-Methylnaphthalene	0.000E+00	0.7	750	0.25	0.35	11	0.000E+00	0.000E+00
1,4-Dichlorobenzene	1.130E-02	0.7	750	0.25	0.35	11	1.349E-01	1.068E-01
Benzene	2.047E-03	0.7	750	0.25	0.35	11	2.442E-02	1.933E-02
Lead, Dissolved	0.000E+00	0.7	750	0.25	0.35	11	0.000E+00	0.000E+00

TABLE W-7 EXPOSURE ASSESSMENT PARAMETERS - INHALATION OF GROUNDWATER
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Exposure Time (hours/day)	0.120	0.120
Inhalation Rate (cu m/hr)	0.600	0.600
Exposure Frequency (days/yr)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time (years)		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE W-8 DAILY INTAKE - ADULT
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	1.293E-02	0.6	298	0.12	25	70	9125	1.086E-05
2-Methylnaphthalene	0.000E+00	0.6	298	0.12	25	70	9125	0.000E+00
1,4-Dichlorobenzene	1.068E-01	0.6	298	0.12	25	70	9125	8.966E-05
Benzene	1.933E-02	0.6	298	0.12	25	70	9125	1.624E-05
Lead, Dissolved	0.000E+00	0.6	298	0.12	25	70	9125	0.000E+00

*not VOCs

TABLE W-9 DAILY INTAKE - CHILD
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	1.293E-02	0.600	48	0.12	15	27	5475	4.534E-06
2-Methylnaphthalene	0.000E+00	0.600	48	0.12	15	27	5475	0.000E+00
1,4-Dichlorobenzene	1.068E-01	0.600	48	0.12	15	27	5475	3.744E-05
Benzene	1.933E-02	0.600	48	0.12	15	27	5475	6.780E-06
Lead, Dissolved	0.000E+00	0.600	48	0.12	15	27	5475	0.000E+00

*not VOCs

TABLE W-10 DAILY INTAKE - ADULT
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/cu.m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	1.293E-02	0.6	298	0.12	25	70	25550	3.877E-06
2-Methylnaphthalene	0.000E+00	0.6	298	0.12	25	70	25550	0.000E+00
1,4-Dichlorobenzene	1.068E-01	0.6	298	0.12	25	70	25550	3.202E-05
Benzene	1.933E-02	0.6	298	0.12	25	70	25550	5.799E-06
Lead, Dissolved	0.000E+00	0.6	298	0.12	25	70	25550	0.000E+00

* not VOCs

TABLE W-11 DAILY INTAKE - CHILD
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/cu.m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	1.293E-02	0.600	48	0.12	15	27	25550	9.715E-07
2-Methylnaphthalene	0.000E+00	0.600	48	0.12	15	27	25550	0.000E+00
1,4-Dichlorobenzene	1.068E-01	0.600	48	0.12	15	27	25550	8.023E-06
Benzene	1.933E-02	0.600	48	0.12	15	27	25550	1.453E-06
Lead, Dissolved	0.000E+00	0.600	48	0.12	15	27	25550	0.000E+00

* not VOCs

TABLE W-12 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH GROUNDWATER
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	0.25	0.25
Dermal Permeability Constant *	0.00084	0.00084
Exposure Frequency (days/year)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	

* Predicted PC (Table 5-7 of U.S. EPA, 1992a)

TABLE W-13 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a) 1.369E-03	0.4	19400	298	0.25	25	70	9125	0.001	3.097E-05
2-Methylnaphthalene	(c) 2.486E-02	0.001	19400	298	0.25	25	70	9125	0.001	1.406E-06
1,4-Dichlorobenzene	(a) 1.130E-02	0.00084	19400	298	0.25	25	70	9125	0.001	5.371E-07
Benzene	(a) 3.900E-03	0.1	19400	298	0.25	25	70	9125	0.001	2.206E-05
Lead, Dissolved	(a) 8.487E-03	0.000004	19400	298	0.25	25	70	9125	0.001	1.920E-09

(a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

(c) Experimentally measured PC value for water, used in the absence of chemical specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).

TABLE W-14 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTIC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a) 1.369E-03	0.4	13300	48	0.25	15	27	5475	0.001	8.866E-06
2-Methylnaphthalene	(c) 2.486E-02	0.001	13300	48	0.25	15	27	5475	0.001	4.026E-07
1,4-Dichlorobenzene	(a) 1.130E-02	0.00084	13300	48	0.25	15	27	5475	0.001	1.538E-07
Benzene	(a) 3.900E-03	0.1	13300	48	0.25	15	27	5475	0.001	6.316E-06
Lead, Dissolved	(a) 8.487E-03	0.000004	13300	48	0.25	15	27	5475	0.001	5.498E-10

(a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

(c) Experimentally measured PC value for water, used in the absence of chemical specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).

TABLE W-15 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a) 1.369E-03	0.4	19400	298	0.25	25	70	25550	0.001	1.108E-05
2-Methylnaphthalene	(c) 2.486E-02	0.001	19400	298	0.25	25	70	25550	0.001	5.023E-07
1,4-Dichlorobenzene	1.130E-02	0.00084	19400	298	0.25	25	70	25550	0.001	1.918E-07
Benzene	(a) 3.900E-03	0.1	19400	298	0.25	25	70	25550	0.001	7.879E-06
Lead, Dissolved	(a) 8.487E-03	0.000004	19400	298	0.25	25	70	25550	0.001	6.839E-10

(a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

(c) Experimentally measured PC value for water, used in the absence of chemical specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).

TABLE W-16 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a) 1.369E-03	0.4	13300	48	0.25	15	27	25550	0.001	1.900E-06
2-Methylnaphthalene	(c) 2.486E-02	0.001	13300	48	0.25	15	27	25550	0.001	8.628E-08
1,4-Dichlorobenzene	1.130E-02	0.00084	13300	48	0.25	15	27	25550	0.001	3.295E-08
Benzene	(a) 3.900E-03	0.1	13300	48	0.25	15	27	25550	0.001	1.353E-06
Lead, Dissolved	(a) 8.487E-03	0.000004	13300	48	0.25	15	27	25550	0.001	1.178E-10

(a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

TABLE W-17 CANCER ESTIMATE - GROUNDWATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects

Site 9, Radar Tower, Alpers CRTC, Alpers, MI

Chemical	Adult CDD (mg/kg day)	Child CDD (mg/kg day)	Adjusted for Absorption	CDI Adjusted for Absorption	SI (mg/kg day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Tetrachloroethylene	1.140E-05	2.857E-06		NO	0.051	B2	Liver	CA EPA 92	5.815E-07		1.457E-07	
2-Methylnaphthalene	2.071E-04	5.190E-05		NO	NO EVIDENCE	B2	Liver	HEAST 93	0.000E+00		0.000E+00	
1,4-Dichlorobenzene	9.471E-05	2.359E-05		NO	0.024	A	Leukemia	IRIS, 1993	2.260E-06		5.663E-07	
Benzene	3.249E-05	8.141E-06		NO	0.029	B2	Kidney		9.422E-07		2.361E-07	
Unsol. Dissolved	7.071E-05	1.772E-05		NO	NO DATA				0.000E+00	3.784E-06	0.000E+00	9.481E-07
Total												

TABLE W-18 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RID (mg/kg day)	Critical Effect	RID Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Trichloroethylene	3.193E-05	1.333E-05	NO	0.01	Hepatotoxicity	IRIS, 1993	1	3.193E-03		1.333E-03	
2-Methylnaphthalene	5.789E-04	2.422E-04	NO	0.03		IRIS, 1993	1	1.933E-02		8.073E-03	
1,4-Dichlorobenzene	2.637E-04	1.101E-04	NO	NO DATA		NA	NA				
Benzene	9.097E-05	3.798E-05	NO	NO DATA		NA	NA				
Lead, Dissolved	1.980E-04	8.268E-05	NO	NO DATA		NA	NA				
Total									2.252E-02		9.406E-03

1) Chronic RID for Pyrene was used.

TABLE W-19 CANCER ESTIMATE - GROUNDWATER INTAKE
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects

Site 9, Radar Tower, Alpena CRTS, Alpena, MI

Chemical	Adult CDI (mg/kg day)	Child CDI (mg/kg day)	CDI Adjusted for Absorption	St mg/kg day ¹ 10018	Weight of Evidence ¹ R2	Type of Cancer Leukemia, Liver	SF Source	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Tetrachloroethylene	3.87E-06	9.75E-07	NO	NO EVIDENCE	C	NA	CA EPA 92	6.97E-09		1.74E-09	
2-Methylnaphthalene	0.00E+00	0.00E+00	NO	NO EVIDENCE	C	NA	CA EPA 92	0.00E+00		0.00E+00	
1,4-Dichlorobenzene	3.20E-05	8.02E-06	NO	0.04	A	NA	IRIS, 1993	1.28E-06		3.20E-07	
Benzene	5.79E-06	1.45E-06	NO	0.029	R2	NA	NA	1.68E-07	1.45E-06	4.21E-08	
Lead, Dissolved	0.00E+00	0.00E+00	NO	NO DATA				0.00E+00		0.00E+00	
Total									1.45E-06		3.64E-07

1) Inhalation SF converted from unit risk.

TABLE W-20 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INHALATION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 9, Radar Tower, Alpena CRIC, Alpena, MI

Chemical	Adult CDI (mg/kg/day)	Child CDI (mg/kg/day)	CDI Adjusted for Absorption	RfD (mg/kg/day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Total Pathway Risk	Children Chemical- Specific Risk	Total Pathway Risk
Tetrachloroethylene	1.08E-05	4.534E-06	NO	0.01	NA	IRIS 93	1	1.08E-03		4.534E-04	
2-Methylnaphthalene	0.00E+00	0.00E+00	NO	0.03	NA	HEAST 93	NA	0.00E+00		0.00E+00	
1,4-Dichlorobenzene	8.95E-05	3.74E-05	NO	0.2	Liver, Kidney	NA	NA	4.48E-04		1.87E-04	
Benzene	1.624E-05	6.789E-06	NO	NO DATA	NA	NA	NA				
Lead, Dissolved	0.00E+00	0.00E+00	NO	NO DATA	NA	NA	NA				
Total									1.534E-03		6.408E-04

1) RfD for corresponding oral RfD was used.

TABLE W-21. CANCER ESTIMATE - DERMAL CONTACT WITH GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects

Site 9: Radio Tower, Alpena, MI

Chemical	Adult CDI (mg/kg/day)	Child CDI (mg/kg/day)	Adjusted for Absorption	GI ^a	SI ^a (mg/kg/day) ⁻¹	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical- Specific Risk	Total Pathway Risk	Child Chemical- Specific Risk	Total Pathway Risk
1,1,1-Trichloroethylene	1.10E-05	1.90E-06	YES	YES	0.051	R2	Liver	CA EPA 92	5.61E-07		9.69E-08	
2-Methylanthracene	5.02E-07	8.62E-08	YES	YES	NO EVIDENCE	R2	Liver	HEAST 93	0.00E+00		0.00E+00	
1,4-Dichlorobenzene	1.91E-07	3.29E-08	YES	YES	0.024	R2	Liver	IRIS, 1993	4.60E-09		7.90E-10	
Benzene	7.87E-06	1.35E-06	YES	YES	0.029	A	Leukemia		2.20E-07		3.92E-08	
Lead, Dissolved	6.86E-10	1.17E-10	YES	YES	NO DATA	R2	Kidney		0.00E+00	7.97E-07	0.00E+00	
Total										7.97E-07		1.38E-07

^a Adjusted from administered to absorbed using and absorption efficiency of: PCE = 1, 1,4 DCE = 1, Benzene = 1, Lead = .05.

TABLE W 22 CHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 9, Radar Tower, Alpena CRTS, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	Adjusted for Absorption	RII* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical- Specific Risk	Child Chemical- Specific Risk	Total Pathway Risk
Tetrachloroethylene	3.097E-05	8.865E-06	NO	0.01	Hepatotoxicity	IRIS, 1993	1	3.10E-03	8.87E-04	
2-Methylanthralene	1.406E-06	4.026E-07	NO	0.005		IRIS, 1993	1	2.81E-04	8.05E-05	
1,4-Dichlorobenzene	5.371E-07	1.538E-07	NO	NO DATA			1			
Benzene	2.206E-06	6.316E-06	NO	NO DATA			1			
Lead, Dissolved	1.920E-09	5.498E-10	NO	NO DATA			1			
Total								3.38E-03		9.67E-04

* Adjusted from administered to absorbed using and absorption efficiency of , PCB = 1.0, 2-Methylanthralene = .017.

Groundwater Solute Transport Model Data - Site 9

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemical's concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.
2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.
3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.
4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.
5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.
6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft²/day at TF4-MW3 to 15,290 ft²/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3-dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^n (h_m - h_s)_i^2]^{0.5}$$

n = number of wells

h_m = measured head

h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = $128.78/38 = 3.3891$
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

- * The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).
- * The initial head data input to the transport model are results of measurements taken in September 1993.
- * Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.
- * Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.
- * The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.
- * The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 9

Several chemicals were detected at Site 9 above MDNR Type A or Type B criteria. These chemicals include PCE, Benzene, 1,4- Dichlorobenzene, Lead, and 2- Methylnapthalene at concentrations of 1.5, 3.9, 18, 15.9, and 47 ug/l, respectively. These chemicals were all present at well RT9MW6, while PCE was detected in wells RT9MW4 and RT9MW5. However, due to numerical errors associated with the very large gradient changes near the sinkhole, PCE was only modeled in RT9MW6. The chemical data was input to the model at the node corresponding to well RT9MW6 and concentrations for the various analytes were monitored in the sinkhole with respect to time.